

Annex B - Part 1  
Technical Specifications



# Yatta Water Supply Project

Complementary works of Yatta Water Supply System

## PARTICULAR TECHNICAL SPECIFICATIONS

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**COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM  
PARTICULAR TECHNICAL SPECIFICATIONS**

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### **Acronyms and Abbreviations**

AFD	Agence française de Développement
EU	European Union
MoA	Ministry of Agriculture
MoH	Ministry of Health
MoL	Ministry of Labor
MoLG	Ministry of Local Government
MoPW	Ministry of Public Works
MoT	Ministry of Transportation
MoTA	Ministry of Tourism and Antiquities
PMU	Projects Management Unit
PLA	Palestinian Land Authority
PNA	Palestinian National Authority
PPWM:	Prepaid Water Meter
PWA	Palestinian Water Authority
RWU	Regional Water Utility
USAID	United States Agency for International Development
UNDP	United Nations Development Program
WBWD	West Bank Water Department

### **Units**

Dunum	1 dunum = 1000m <sup>2</sup>
h	hours
Hz	Hertz
%	percent
"	inch
Cm	Centimeter
kg/d	kilogram per day
kN	Kilo Newton
kW	Kilo Watt
l.m or m'	linear meter
masl	Meter Above Sea Level
m <sup>3</sup>	cubic meter
m <sup>3</sup> /d	cubic meter per day
m <sup>3</sup> /h	cubic meter per hour
mg	milligram
mm	millimetre
l/c/d or lpcd	litre per capita per day
l/s	litre per second

## **1 GENERAL PRELIMINARIES**

### **1.1 SPECIFICATIONS**

- A. These General Technical Specifications should be read in conjunction with the Palestinian Product Standards which form a part of these Specifications.
- B. The Particular Technical Specifications shall prevail on the “General Technical Specifications for the Construction of Concrete Water Tanks” (PNA – PWA – version September 2013, hereafter designated as “General Technical Specifications” or “General Specifications”) and cover all aspects not included in the General Technical Specifications.
- C. Materials and works not covered by the General or Particular Specifications will be specified either in the Special (Particular) Conditions of Contract or in the Bill of Quantities or drawings and shall be approved by the Engineer.

### **1.2 WORKS TO BE EXECUTED**

The works to be executed shall be as described in these Particular Technical Specifications and / or in the drawings and Bill of Quantities.

### **1.3 ABBREVIATIONS**

Refer to General Technical Specifications

### **1.4 STANDARDS**

Refer to General Technical Specifications

### **1.5 UNITS OF MEASUREMENT**

Refer to General Technical Specifications

### **1.6 PRELIMINARY WORKS: MOBILIZATION AND DEMOBILIZATION**

#### **1.6.1 MOBILIZATION SCOPE**

As required for the proper performance and completion of the Work, mobilization shall include, but not limited to, the following principal items:

1. Move onto the site all the Contractor’s plant and equipment required for the first month’s operation.
2. Install temporary construction power, wiring, and lighting facilities
3. Establish a fire protection plan and safety program, Environmental and Social Protection
4. Secure construction water supply

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5. Provide and furnish field office trailers/offices for the Contractor. These offices shall be located on site
6. Arrange for and erect the Contractor's work and storage yard, employee's facilities, temporary etc.
7. Submit all required insurance certificates and bonds.
8. Obtain all required permits.
9. Post all required notices.
10. Have the Contractor's Project Manager and the required staff at the job site full time.
11. Submit a detailed construction schedule acceptable to the Engineer and Owner.
12. Locate and flag the limits of construction and clearing.
13. Submit A breakdown price for all BOQ items.
14. Submit and approval of all financial and insurance costs; insurances, permits, any costs for bank guaranties, etc
15. Protective Equipment and Clothing

### **PAYMENT FOR MOBILIZATION**

The Contractor's attention is directed to the condition that no payment for mobilization, or the part thereof, will be approved for payment under the Agreement until all mobilization items listed above have been satisfactorily completed as specified in addition to provide the required under items 1.3 and 1.4. The full payment of the Lump sum for Mobilization will be paid after satisfactory completion of mobilization components, according to the related item in the Bill of Quantities.

### **1.6.2 OBSTACLES**

Allow for every expenses and works to remove carefully any obstacles such as trees, fences, old culverts, steel structures etc. The price shall also include reinstatement and of dismantled obstacles except for the trees. The Contractor shall submit a dilapidation video and get approval before removing any obstacle's.

This shall be an on-going task. It shall be paid once with the Third IPC.

### **1.6.3 PROJECT SIGN BOARDS**

Main sign boards with size 2.0 x 1.5m, in accordance with the Engineer instructions. The boards shall be designed (foundation, galvanized steel board, galvanized steel poles etc.) by the Contractor and approved by the Engineer.

### **1.6.4 FACILITIES PROVIDED TO THE ENGINEER OR EMPLOYER**

The Contractor shall make available one rent vehicle for the sole use of the Client for the whole contract period (14 months). If the vehicle be out of order for repair or maintenance, a replacement shall immediately be made available. The road vehicles shall be insured all-risk for driving by any fully-licensed driver authorized by the client, on and off site, both inside and outside the Contractor's working hours. Requirements for the rent vehicle are listed here under:

- One (1) 4X4 vehicles suitable for off-road travel – when provided, the vehicle shall be new in very good condition with no more than two (3) years old;
- The Contractor shall provide all fuel and lubricants for the vehicle to travel within the Site and out the site for

# COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM

## PARTICULAR TECHNICAL SPECIFICATIONS

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ONLY max 3500 Km per month.

In addition to what in the general specifications, site offices for the Engineer and Client shall be for (5 people) minimum area 90 m<sup>2</sup> including maintenance, furniture, running costs, etc. the Contractor shall provide and maintain:

- A meeting room accommodating 10 persons.
- A separate room for the use of the Employer. This room shall not be less than 15m<sup>2</sup> floor area and shall have a minimum headroom of 2.4m, furnished with 2 desks (1.40 x 0.80 meters), 4 chairs, 2 cupboards, 2 latest model disk computers, 1 color printer A4, scanner A4 with OCR and 2 latest mobiles with all their accessories and all stationary needed.
- Sanitary facilities (toilets and wash basin) properly equipped with water and wastewater connections

They shall also be provided with adequate water, electricity, telephone and Internet connections. The equipment and furniture shall be handed over at the end of the project in good condition and complete function to the Employer at demobilization stage. The Contractor shall therefore do a final check-up, repair and maintenance for all those facilities before handing them over to the Employer.

These rooms shall be cleaned by the Contractor daily and all related utilities will be at the Contractor's own expense.

Moreover, the Contractor shall provide adequate car parking space for the Employer and the Engineer.

The Contractor shall purchase and deliver to the site, to the Employer the following:

- Two heavy-duty laptops of the latest model with all their accessories to be handed over to the Employer: Within (1) one month from commencement, the Contractor shall submit to the Employer, catalogues, brochures, specifications and prices, etc., relating to the various types of laptops. Details shall be supplied from at least three manufacturers.
- The laptops shall be delivered new within one month after selection by the Employer

### 1.6.5 PROJECT EXISTING MATERIALS

Allow for every expense and works to move carefully all existing project Material (Pipes, valves, fittings, etc.) from Yata Municipality/PWA storage yard/warehouse in Yatta to the Contractor Storage Area/warehouse. The price shall include the loading and unloading, Storage area approved by the Engineer, Storage keepers, security, preparation of storage in/out system, inventory before and after the implementation of the project, cleaning, sand blasting, welding, epoxy coating, repair and refabricating of all materials to make suitable for the use in the project.

The Contractor shall be responsible of the material during the works. The Contractor shall submit to the Engineer two days before implementing the works the required materials and shall get approval from the Engineer before using any materials.

### 1.6.6 DEMOBILIZATION

As required for the proper performance and completion of the Work, demobilization shall include, but not limited to, the following principal items:

1. Remove the Contractor's field offices and trailer used for storage.
2. Remove all temporary power and utility lines.
3. Remove ant temporary fencing, roadways and parking areas.
4. All areas disturbed during construction are seeded or sodded per the Contract Documents.
5. Remove contract signs.
6. Meet with the Engineer or Owner on site and have the site approved and acceptable as is.

### **1.6.7 PAYMENT FOR DEMOBILIZATION**

Payment for demobilization will be made in the final application for payment. The full payment of the Lump sum for Demobilization will be paid after satisfactory completion of demobilization components, according to the related item in the Bill of Quantities.

## **1.7 ENVIRONMENTAL AND SOCIAL PROTECTION**

The Contractor shall make every reasonable endeavour both by means of temporary works and by the use of particular plant or silencing devices to ensure that the level of noise or pollution resulting from the execution of the works does not constitute a nuisance.

The Contractor shall take all such precautions as may be necessary in the conduct of the work to avoid water pollution, air pollution, noise pollution harmful to health, spreading of plant diseases and pests or damage to natural resources or the environment, all as is consistent with good practice and as required by applicable laws, ordinances and regulations or lawful orders or authority having jurisdiction, as well as required by the Environmental and Social Management Plan (ESMP) established by the Employer

## **1.8 PROTECTIVE EQUIPMENT AND CLOTHING**

The Contractor shall provide and maintain all necessary protective and safety equipment and clothing for the operative and site staff (the Contractor, the Employer and the Engineer) and as instructed by the Engineer.

In addition to above; the Contractor shall also provide the Employer "Em" and Engineer "En" the following safety equipment:

- Heavy-duty white hard hats (5);
- Heavy-duty safety jackets with pockets (5);
- Heavy-duty safety shoes (5);
- Heavy duty Kits for measurement 5. different types of meters, 5 laser meters, 10 field calculators, 2 digital coating and thickness measurement tools...ect

Brochures and specifications for this safety and field equipment will be submitted to the Employer for approval prior to delivery.

## **2 SUBMITTALS**

### **2.1 GENERAL**

Inquiries: Direct to Engineer regarding procedure, purpose, or extent of Submittal.

Timeliness: Schedule and make submissions in accordance with requirements of individual Specification sections and in such sequence as to cause no delay in Work.

#### **2.1.1 IDENTIFICATION OF SUBMITTALS**

Complete, sign, and transmit with each Submittal package, one Transmittal of Contractor's Submittal Form (see below). Identify each Submittal with the following numbering and tracking system:

- Sequentially number each Submittal.
- Resubmission of a Submittal will have original number with sequential alphabetic suffix.
  - Format: Orderly, indexed with labeled tab dividers.
  - Show date of submission.
  - Show Project title and owner's contract identification and contract number.
  - Show names of Contractor, Sub Contractor (if any) and manufacturer as appropriate.
  - Identify, as applicable, Contract Document section and paragraph to which Submittal applies.
  - Identify Submittal type; submit only one type in each Submittal package.
  - Identify and indicate each deviation or variation from Contract Documents.
- Resubmissions: Clearly identify each correction or change made.

#### **2.1.2 INCOMPLETE SUBMITTAL SUBMISSIONS**

Engineer will return the entire Submittal for Contractor's revision/correction and resubmission.

Submittals which do not clearly bear Contractor's specific written indication of Contractor review and approval of Submittal or which are transmitted with an unsigned or uncertified submission form or as may otherwise be required will be returned to Contractor not reviewed.

#### **2.1.3 NO SPECIFIED SUBMISSIONS**

Submissions not required under the Contract Documents and not shown on submissions will not be reviewed and will be returned to Contractor.

#### **2.1.4 ENGINEER'S REVIEW**

Engineer will act upon Contractor's Submittal and transmit response to Contractor not later than 30 days after receipt, unless otherwise specified. Resubmittals will be subject to the same review time.

#### **2.1.5 SCHEDULE DELAYS**

No adjustment of Contract Times or Price will be allowed due to Engineer's review of Submittals, unless all of the following criteria are met:

- Contractor has notified Engineer in writing that timely review of Submittal in question is critical to progress of Work, and has received Engineer's written acceptance to reflect such on current accepted submissions and progress schedule. Written agreement by the Engineer to reduce Submittal review time will be made only for unusual and Contractor -justified reasons. Acceptance of a progress schedule containing Submittal review times less than specified or less than agreed to in writing by Engineer will not constitute Engineer's acceptance of the review times.

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- Engineer has failed to review and return first submission of a Submittal within agreed time indicated on current accepted schedule of submissions or, if no time is indicated thereon, within 30 days after receipt.
- Contractor demonstrates that delay in progress of Work is directly attributable to Engineer's failure to return Submittal within time indicated and accepted by Engineer.

*No adjustment of Contract Times or Price will be allowed due to delays in progress of Work caused by rejection and subsequent resubmission of Submittals, including multiple resubmissions.*

### 2.1.6 COPIES

- Shop Drawings and Product Data: Two and one reproducible, except copyrighted documents.
- Samples: Two unless otherwise specified in individual Specification sections.

### 2.1.7 IDENTIFY AND INDICATE:

- Pertinent Drawing sheet(s) and detail number(s), products, units and assemblies, and system or equipment identification or tag numbers.
- Critical field dimensions and relationships to other critical features of Work.
- Samples: Source, location, date taken, and by whom.
- Each deviation or variation from Contract Documents.
- Design Data: When specified, provide Project-specific information as required and as necessary to clearly show calculations, dimensions, logic and assumptions, and referenced standards and codes upon which design is based.

### 2.1.8 PREPARATION

- Format: Whenever possible, schedule for and combine Shop Drawings and Samples required for submission in each Specification section or chapter into a single Submittal package. Also combine product data for like items into a single Submittal package.
- Present in a clear and thorough manner and of sufficient detail to show kind, size, arrangement, and function of components, materials, and devices and compliance with Contract Documents. Identify details by reference to sheet and detail, and schedule or room numbers shown on Drawings.
- Reproducible Copy:
  - Preferred Minimum Sheet Size: A4 and A3, suitable for photocopying.
  - Larger than A3: A1 preferred.
- Piping Systems: Drawn to scale.
- Product Data: Clearly mark each copy to identify pertinent products or models and show performance characteristics and capacities, dimensions and clearances required, wiring or piping diagrams and controls, and external connections, anchorages, and supports required.
- Equipment and Component Titles: Identical to title shown on Drawings.
- Manufacturer's standard schematic drawings and diagrams as follows:
  - Modify to delete information that is not applicable to Work.
  - Supplement standard information to provide information specifically applicable to Work.

### 2.1.9 SHOP DRAWING DISPOSITION

Engineer will review, mark, and stamp as appropriate and distribute marked-up copies as noted:

- Approved as Submitted (for incorporation in Work):

# COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM

## PARTICULAR TECHNICAL SPECIFICATIONS

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- One copy furnished Owner.
  - One copy furnished Resident Project Representative.
  - One copy retained in Engineer's file.
  - Remaining copies returned to Contractor appropriately annotated.
  - Contractor may begin to implement activities to incorporate specific product(s) or Work covered by Submittal.
- Approved as Noted (for incorporation in Work):
- One copy furnished Owner.
  - One copy furnished Resident Project Representative.
  - One copy retained in Engineer's file.
  - Remaining copies returned to Contractor appropriately annotated.
  - Contractor may begin to implement activities to incorporate product(s) or Work covered by Submittal, in accordance with Engineer's notations.
- Disapproved:
- One copy furnished Resident Project Representative.
  - One copy retained in Engineer's file.
  - Remaining copies returned to Contractor appropriately annotated.
  - Contractor shall make corrections or develop replacement and resubmit (in same manner and quantity as specified for original submission).
  - Submittal is not approved.
- Incomplete:
- One copy furnished Resident Project Representative.
  - One copy retained in Engineer's file.
  - Remaining copies returned to Contractor appropriately annotated.
  - Contractor shall complete and resubmit or submit missing portions.
  - Submittal is not approved.

### 2.1.10 SAMPLE DISPOSITION

Same as Shop Drawing disposition; samples will not be returned.

## 2.2 ADMINISTRATIVE SUBMITTALS

### 2.2.1 COPIES

Submit four copies.

### 2.2.2 DESCRIPTION

Submittals that are not Shop Drawings or Samples, or that do not reflect quality of product or method of construction. May include, but not limited to those Submittals identified below.

### 2.2.3 APPLICATIONS FOR PAYMENT (AND CASH ALLOWANCE DATA AND VALUES)

Meet requirements of General Conditions and MEASUREMENT AND PAYMENT.

#### **2.2.4 PROGRESS REPORTS AND QUANTITY CHARTS**

As may be required in, Project Control / Procedures.

#### **2.2.5 SCHEDULES**

■ Progress Schedule(s): Meet the requirements of Project Control / Procedures.

■ Schedule of Submittal Submissions:

- Prepare and submit, preliminary list of submissions grouped by Contract Document article/paragraph number or Specification section number, with identification, numbering and tracking system as specified under Paragraph Identification of Submittals and as approved by Engineer.

■ Include only the following required submissions:

- Shop Drawings and Samples.
- Training plans (if required by other sections).
- Test procedures.
- Operation and maintenance manuals (if required by other sections).
- Record documents.
- Specifically required certificates, warranties, and service agreements.
- Coordinate with progress schedule and prepare submissions to show for each Submittal, at a minimum, the following:

#### **2.2.6 SUBMITTALS REQUIRED BY LAWS, REGULATIONS, AND GOVERNING AGENCIES**

- Submit promptly notifications, reports, certifications, payrolls, and otherwise as may be required, directly to the applicable federal, state, or local governing agency or their representative.
- Transmit to Engineer for Owner's records one copy of correspondence and transmittals (to include enclosures and attachments) between Contractor and governing agency.

#### **2.2.7 DISPOSITION**

Engineer will review, stamp, and indicate requirements for resubmission or acceptance on Submittal as follows:

■ Accepted:

- Acceptance will indicate that Submittal conforms to content of Contract Documents.
- Contractor may proceed to perform related Work.
- One copy shall be furnished to Owner.
- One copy shall be furnished to Resident Project Representative.
- One copy is retained in Engineer's file.
- Remaining copies are returned to Contractor.

■ Rejected as Noted:

- One copy is retained in Engineer's file.
- Remaining copies are returned to Contractor
- Contractor shall revise/correct and resubmit.

## **2.3 QUALITY CONTROL SUBMITTALS**

### **2.3.1 CERTIFICATES**

- Manufacturer's Certificate of Compliance.
- Certificates of Successful Testing or Inspection: Submit when testing or inspection is required by Laws and Regulations or governing agency or specified in the individual Specification sections.
- Manufacturer's Certificate of Proper Installation.

### **2.3.2 STATEMENTS OF QUALIFICATION**

Evidence of qualification, certification, or registration. As required in these Contract Documents to verify qualifications of professional land surveyors, Engineers, materials testing laboratories, specialty Sub Contractors, trades, specialists, consultants, installers, and other professionals.

### **2.3.3 FIELD SAMPLES**

Provide as required by individual Specifications and as may be required by Engineer during progress of Work :

- Written Test Reports of Each Test and Inspection: As a minimum, include the following:
- Date of test and date issued, Project title and number, testing laboratory name, address, and telephone number, and name and signature of laboratory inspector.
- Date and time of sampling or inspection and record of temperature and weather conditions.
- Identification of product, Specification section, location of Sample, test or inspection in the Project, type of inspection or test with referenced standard or code, certified results of test.
- Compliance with Contract Documents, or identifying corrective action necessary to bring materials and equipment into compliance.
- Provide an interpretation of test results, when requested by ENGINEER.

### **2.3.4 DISPOSITION**

Similar to 2.2.7.

## **2.4 CONTRACT CLOSEOUT SUBMITTALS**

### **2.4.1 DISPOSITION**

Similar to 2.2.7.

### **2.4.2 RECORD DRAWINGS**

Throughout the project, maintain a current complete set of project drawings with all variations plainly marked. Each month, or as otherwise agreed, submit to Engineer a current listing and description of each variation incorporated into the work since the preceding submittal. Contractor will prepare a set of Contract Drawings, with

## **COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM PARTICULAR TECHNICAL SPECIFICATIONS**

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all changes marked in red and including all variations made in materials, locations, and dimensions of the work. The Contractor shall certify that these drawings represent the actual "as built" condition of the project.

After approval of the Engineer to these drawings, the Contractor will rely upon these drawings in the preparation of Record Drawings of the Work.

The Contractor shall submit to the Engineer three sets of the final record drawings on paper form in addition to one copy of digital form on Auto Cad format at least version 14.

**COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM  
PARTICULAR TECHNICAL SPECIFICATIONS**

**TRANSMITTAL OF CONTRACOR'S SUBMITTAL FORM**

**TRANSMITTAL OF CONTRACTOR'S SUBMITTAL**

(ATTACH TO EACH SUBMITTAL)

**TO:** \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Submittal No.: \_\_\_\_\_

New Submittal  Resubmittal

Previous Submittal No.: \_\_\_\_\_

Project: \_\_\_\_\_

Contract No.: \_\_\_\_\_

Specification Section No.: \_\_\_\_\_

**FROM:** \_\_\_\_\_  
 Contractor

**(Cover only one section with each transmittal)**

Schedule Date of Submittal: \_\_\_\_\_

**SUBMITTAL TYPE:**     Shop Drawing                       Administrative                       Sample  
                                   Quality Control                       Contract Closeout                       "Or-Equal"/Substitute

The following items are hereby submitted:

Number of Copies	Description of Item Submitted (Type, Size, Model Number, Etc.)	Spec. Para. No.	Drawing or Brochure Number	Contains Variation to Contract	
				No	Yes

Contractor hereby certifies that (i) Contractor has complied with the requirements of Contract Documents in preparation, review, and submission of designated Submittal and (ii) the Submittal is complete and in accordance with the Contract Documents and requirements of laws and regulations and governing agencies.

By: \_\_\_\_\_  
 Contractor (Authorized Signature)

### **3 MEASUREMENT AND PAYMENT**

#### **3.1 GENERAL**

The whole of the Works under this Contract shall be priced under the Bill of Quantities (BOQ). Payment for the various items of the BOQ, as further specified herein, shall include all compensation to be received by the Contractor for furnishing, installation completely and functioning the system described in the Contract Documents but not limited to :

All tools, equipment, furnish materials, installation requirements, manufactured articles and services, all labour, operations, and incidentals appurtenant to the items of work being described, as necessary to complete the various items of the WORK. All in accordance with the requirements of the Contract Documents, including all appurtenances thereto, and including all costs of permits, fees, cost of needed field and laboratory tests and cost of compliance with the regulations of public agencies having jurisdiction.

No separate payment will be made for any item that is not specifically set forth in the Bill of Quantities, and all costs therefore shall be included in the prices named in the Bill of Quantities for the various appurtenant items of work.

No partial bids will be accepted

In general, these works include but not limited to the following:

1. Prepare and submit to the Engineer for his review and approval all the required paper works mentioned in the Contract but not limited to: submittals, schedule, project control procedures, quality control program, shop drawings, product data, samples and act.
2. Design the detail alignment depending on the steel pipe and fittings or any other materials
3. Use the allowable deflection angle between the pipes to avoid as much as possible using bends.
4. Prepare and furnish facilities for site offices as required and described in the bid documents.
5. Purchase all equipment and materials as per the specifications that are enclosed in the final bidding documents. .
6. Provide all required certifications and documentations from the manufacturers.
7. Provide all required certifications and documentations authenticated by all concerned authorities as per the export rules and regulations of the manufacturer country and import rules and regulations of Israel.
8. Ship the equipment and materials to a Port in Israel.
9. Provide marine insurance for shipment
10. Provide all equipments, tools and labor required to construct the system as per the drawings and specifications.
11. Install and tests completely and operate the system in accordance with drawings and specifications
12. Obtain all required permits and documentations by all concerned authorities as per the rules and regulations of the Palestinian authority and Israeli sides.
13. Provide warranties as specified.
14. Provided qualified staff and equipment to implement all works (networks, transmission pipe, tanks, pumping stations, ...). This staff shall be able to work in all areas of the West Bank under the jurisdiction of the Palestinian Authority areas.
15. Transport all equipment and materials to the West Bank including arrangements for protection and security.
16. Provide arrangement for on-site training as specified
17. Contractor must have designated representative in the West Bank available for project coordination and progress meetings until the end of the project.

## **3.2 PRICING THE BOQ AND PAYMENT**

### **3.2.1 PRICING THE BOQ**

All incidental works that are not mentioned as an item in the BOQ and expense in connection with the completion of the Work under all requirements and conditions of this Contract shall be considered a subsidiary obligation of the Contractor and all such costs shall be included in the appropriate items unit price in the BOQ in connection with which the costs are incurred.

Refer to the Tables in the Bill of Quantities for a listing of the BOQ items.

The quantities shown in the BOQ are approximate numbers and not fixed, the contractor is full responsible to do the required survey and calculations to determine the correct dimensions and quantities. Therefore, the quantities can be changed without any adjustment or addition to the unit prices if the total cost of the changes is less than or equal 10% of the total contract price or the change in the quantity of any item is less than or equal 25% of the quantity of that item in the BOQ.

In addition to the BOQ, the Contractor should submit a list of detailed unit (Break Down) cost for all the materials, machines and labors which will be used in the project such as pipes, valves, base course, asphalt, reinforced concrete, excavators, engineers, workers and act. This Break Down will be the base to calculate change order, claims or weight activities through the implementation of the project.

At the time of preparing this documents, there is number of activities are on going. For example, most of the unpaved road that shown on the drawing may be change to paved road at the implementation time. Therefore, the Bidder and the Contractor later shall put his price and then create his shop drawing depending on the latest available information.

### **3.2.2 GENERAL PROCEDURE OF PAYMENT**

All payment will follow the general procedure as defined in Section VIII. General Conditions (GC) and Section IX. Particular Conditions (PC) of the contract. This procedure includes:

- Advance payment;
- Retention;
- Payment for Plants and Materials when delivered to the site;
- Payment after the issue of an Interim Payment Certificate;
- Etc.

### **3.2.3 GENERAL PRICES FOR ENTIRE PROJECT**

#### **3.2.3.1 General Notes**

Unit prices of all items of earth works shall include the following:

Cleaning the site from all surplus back-fill material, results of excavation. Also fees to the related authorities will be at the contractor's own expenses.

Payment for excavation/backfilling and reinstatement will be based on the volumes and surfaces consequently determined by the approved drawings

#### **3.2.3.2 Excavation for pipe laying**

Excavate in all types of soil and rock (hardpan, boulders, rubble and similar materials), according to the trench type in the contract drawings and to the general technical specifications starting by Clearing, grubbing of top soil, specified in the General Technical Specifications and up to the satisfaction of the engineer.

## COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM PARTICULAR TECHNICAL SPECIFICATIONS

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Excavation in asphalted areas must start by using asphalt cutting machine, compressors or hand excavating might be needed for the narrow roads or any needed place to reach the minimum depth and width required in the drawings.

Dispose immediately of excavated material to locations acceptable to the engineer and related authorities. All related works of this item should be implemented in accordance with Specifications, drawings and engineer's approval.

Measurement for excavation will be based on the volume determined by the approved drawings.

Payment for excavation will be made at the unit price per cubic meter stated in the Bill of Quantities.

### 3.2.3.3 BACKFILLING FOR TRENCHES

**Soft Backfilling:** supplying and backfilling (surrounding the pipe) by using fine crushed gravel 50% equivalent sand according to the general technical specifications. This material shall be placed 150 mm below the invert level up to 150 mm over the crown of the pipe and for the full width of the trench .the pipes should be supported on sacks filled with fine crushed gravel 150 mm height every 6m .

Warning tape: supplying and laying warning tape. For HDPE pipes the warning tape includes a continuous 4 mm galvanized wire.

**Final Backfilling:** supplying, backfilling of the excavated trench by using Crushed gravel (HUMSIEH), grain size analysis must be carried out each 150 m by the contractor and at his own expense with final layer of compacted base course. Or compacted base course in layers

This unit price does not cover concrete encasement for pipes crossing main roads, sewers, and concrete over pipes installed in very low depth caused by unseen obstacles and where needed and/or requested by the supervising engineer. This item is covered in the BoQ General Prices

All work should be completed to the base course according to the contract drawings, General Technical Specifications of contract and the instructions of the supervision engineer.

Measurement for Backfilling of trenches will be based on the linear meter determined by the approved drawings and related cross section.

Payment for Backfilling of trenches will be made at the unit price per cubic meter stated in the Bill of Quantities

### 3.2.3.4 REINSTATEMENT

Reinstatement: supplying and compaction of asphalt layer/s (if any) and reinstatement of the final layer as the existing conditions.

Compaction tests must be carried out each 150 m by the contractor and at his own expense and reinstatement of the working site; asphalt, concrete, tiles, base course, and any other existing surface.

All work should be completed according to the contract drawings, General Technical Specifications of contract and the instructions of the supervision engineer.

Measurement for reinstating of trenches will be based on the surfaces determined by the approved drawings

Payment for reinstating of trenches will be based on the surfaces (square meter) determined by the approved drawings

## 3.2.4 INSTALLATION OF PIPES (INSTALLATION OF PIPES)

### 3.2.4.1 GENERAL NOTES

The price shall constitute full compensation for furnishing and installing all such pipe and fittings, with external and internal coating as in the specifications, including but not limited to complete topographical survey and detailing final alignment, all labour, equipment and materials, alignment clearance, test pits for exploratory excavations, shoring, dewatering, all even beyond the dimensions shown, marker tape, pipe

## COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM PARTICULAR TECHNICAL SPECIFICATIONS

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jointing, polyethylene sleeve, heat-shrink tubular sleeve around all joints, pipe markers, connection to fittings and structures.

The test pits shall include excavation, monitoring, detailing/sketching of information (utilities, rock elevation, road elevation, specific location, dimensions, etc.), including all labor, equipment and materials as required by the Contract Documents. Also, include the back filling of the excavation and reinstatement of the road surface.

Measurement for payment for pipes and fittings will be based upon the number of linear meters of such pipe and fittings actually and completely placed according to the drawings and specifications.

Measurement for the pipes and fittings will be determined by the approved drawings. The lengths of pipe and the fittings inside chambers will be excluded from this measurement as they are already part of the lump sum for the chambers.

Payment for the pipes and fittings will be made at the unit price per linear meter stated in the Bill of Quantities which includes the cost of cleaning, hydraulic test, disinfection...

### 3.2.4.2 STEEL PIPES

#### **Supplying and Installation of pipes**

The works shall be completed according to the drawings, General Technical Specifications of the contract and the instruction of the supervising engineer.

Spreading along the route of pipe lines, install pipes and lowering inside the ditches, including joining of elbow, future connection tees if any with blind flange if needed, warning tape, so as the pipe line will be always in the centre of the trench.

Damaged to any part of the pipe should be cut and removed outside according to the specifications and standards.

The price includes any work or instruments or materials needed to carry the disconnection of old pipes and the connection of the new pipes with existing one.

The price includes any work or instruments or materials needed to carry the cutting, shaping of the pipes and fittings and installing the gaskets and rings at the pipe joints and welding points.

The price also includes supplying, loading, transporting and offloading the pipes to the work location.

The price also includes the cost of cleaning, hydraulic and disinfection of pipes and fittings test (including supply of the needed quantities of water for tests and disinfection).

The price includes all fittings (Bends, Reducer, Tee, coupling, ...) as indicated on the approved drawings

Measurement for the pipes and fittings will be determined by the approved drawings. The lengths of pipe and the fittings inside chambers will be excluded from this measurement as they are already part of the lump sum for the chambers.

Payment for the pipes and fittings will be made at the unit price per linear meter stated in the Bill of Quantities

### 3.2.4.3 GATE VALVE

#### **Supplying and installation of gate valves**

The work shall be completed according to the approved drawings, general technical specifications of the contract and the instruction of the supervising engineer.

Supply, install Gate valve facilities according to approved drawings and specifications. Rate includes excavation in any kind of materials, and if any, reinforced concrete, form work, blinding concrete, base course under manhole base, cast iron heavy duty frame and cover, rungs, concrete support, all other materials needed to complete the gate valve installation, all rib-rab material and works, laying, jointing,

## **COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM PARTICULAR TECHNICAL SPECIFICATIONS**

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testing, backfilling using base course, compaction on layers not exceeding 250 mm to 95% maximum dry density and according to AASHTO T191, T180 , reinstatement and commissioning complete.

The price also includes loading, transporting, offloading the gate valves from the storage yard to the work location.

Measurement for gate valve facilities will be based upon the number actually and completely placed according to the approved drawings and specifications

Payment for gate valve facilities will be made at lump sum stated in the Bill of Quantities

### **3.2.4.4 WASHOUT**

#### **Supplying and installation of washout**

The work shall be completed according to the approved drawings, general technical specifications of the contract and the instruction of the supervising engineer.

Supply, install and construct washout facilities according to approved drawings and specifications. Unit price includes excavation in any kind of materials , and if any, reinforced concrete, form work, blinding concrete, base course under manhole base, cast iron heavy duty frame and cover ,rungs, all types of valves, tee with flanged branch on main, elbows, flanges, reducer, concrete support, all other materials needed to complete the washout installation, all rib-rab material and works, laying, jointing, testing, backfilling using base course, compaction on layers not exceeding 250 mm to 95% maximum dry density and according to AASHTO T191, T180 , reinstatement and commissioning complete.

The work shall be completed according to the approved drawings, general technical specifications of the contract and the instruction of the supervising engineer.

Measurement for washout facilities will be based upon the number actually and completely placed according to the approved drawings and specifications.

Payment for washout facilities will be made at lump sum stated in the Bill of Quantities.

### **3.2.4.5 AIR VALVE**

#### **Supplying and installation of air valve**

The work shall be completed according to the approved drawings, general technical specifications of the contract and the instruction of the supervising engineer.

Supply, install and construct Air release Valve facilities according to approved drawings and specifications. Rate includes excavation in any kind of materials , and if any, reinforced concrete, form work, blinding concrete, base course under manhole base, cast iron heavy duty frame and cover, rungs, all types of valves, tee with flanged branch on main, elbows, flanges, reducer, concrete support, all other materials needed to complete the Air valve installation, all rib-rab material and works, laying, jointing, testing, backfilling using base course, compaction on layers not exceeding 250 mm to 95% maximum dry density and according to AASHTO T191, T180 , reinstatement and commissioning complete. The work shall be completed according to the approved drawings, general technical specifications of the contract and the instruction of the supervising engineer.

Measurement for Air Valve facilities will be based upon the number actually and completely placed according to the approved drawings and specifications.

Payment for air valve facilities will be made at lump sum stated in the Bill of Quantities.

### **3.2.4.6 BULK DELIVERY FLOW METER**

#### **Flow meter and valves chambers**

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The work shall be completed according to the approved drawings, general technical specifications of the contract and the instruction of the supervising engineer.

Supply, install and construct Flow Meter chamber according to drawings and specifications. Rate includes excavation in any kind of materials , reinforced concrete, form work, blinding concrete, base course under manhole base, cast iron heavy duty frame and cover ,rungs, all types of valves, dressers (if any), tee with flanged branch on main, elbows, flanges, reducer, all steel piping from chamber to drain/washout , concrete support, reinforced concrete wall outside the chamber, drainage pit, chamber vent pipes, all other materials needed to complete the Flow meter installation, all rib-rab material and works, laying, jointing, testing, supplying and implementing two cold bitumen layers to the external faces of buried all buried concrete elements, backfilling using base course, compaction on layers not exceeding 250 mm to 95% maximum dry density and according to AASHTO T191, T180 , reinstatement and commissioning complete. The work shall be completed according to the drawings, general technical specifications of the contract and the instruction of the supervising engineer.

Measurement for Bulk Delivery Flow Meter chambers will be based upon the number actually and completely placed according to the approved drawings and specifications.  
Payment for Bulk Delivery Flow Meter facilities will be made at lump sum stated in the Bill of Quantities.

### **3.2.4.7 ZONE FLOW WATER METER**

#### **Flow meter and valves chambers**

The work shall be completed according to the approved drawings, general technical specifications of the contract and the instruction of the supervising engineer.

Supply, install and construct Flow Metre chamber according to drawings and specifications. Rate includes excavation in any kind of materials , reinforced concrete, form work, blinding concrete, base course under manhole base, cast iron heavy duty frame and cover ,rungs, all types of valves, dressers, tee with flanged branch on main, elbows, flanges, reducer, all piping from chamber to washout , concrete support, reinforced concrete wall outside the chamber, drainage pit, chamber vent pipes, all other materials needed to complete the Flow Meter installation, all rib-rab material and works, laying, jointing, testing, supplying and implementing two cold bitumen layers to the external faces of buried all buried concrete elements, backfilling using base course, compaction on layers not exceeding 250 mm to 95% maximum dry density and according to AASHTO T191, T180 , reinstatement and commissioning complete. The work shall be completed according to the drawings, general technical specifications of the contract and the instruction of the supervising engineer.

Measurement for Zone Flow Water Meter Chambers will be based upon the number actually and completely placed according to the approved drawings and specifications.  
Payment for Zone Flow Water Meter facilities will be made at lump sum stated in the Bill of Quantities

### **3.2.4.8 PRV (PRESSURE REDUCING VALVE) CHAMBER**

#### **PRV Chambers**

The work shall be completed according to the approved drawings, general technical specifications of the contract and the instruction of the supervising engineer.

Supply, install and construct PRV chamber according to drawings, and specifications. Rate includes excavation in any kind of materials , reinforced concrete, form work, blinding concrete, base course under manhole base, cast iron heavy duty frame and cover ,rungs, all types of valves, dressers, tee with flanged branch on main, elbows, flanges, reducer, all steel piping from chamber to drain/washout , concrete support, reinforced concrete wall outside the chamber, drainage pit, chamber vent pipes, all other materials needed to complete the PRV installation, all rib-rab material and works, laying, jointing, testing, supplying and implementing two cold bitumen layers to the external faces of all buried concrete elements, backfilling using base course, compaction on layers not exceeding 250 mm to 95% maximum dry density and according to AASHTO T191, T180 , reinstatement and commissioning complete. The work shall be completed according to the drawings, general technical specifications of the contract and the instruction of the supervising engineer.

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Measurement for PRV facilities will be based upon the number actually and completely placed according to the approved drawings and specifications.

Payment for PRV facilities will be made at lump sum stated in the Bill of Quantities

### **3.2.5 SPARE PARTS**

Measurement for payment for Spare parts will be at Engineer-verified quantities for the items listed in the Bill of Quantities.

Payment – Spare parts is meant to be materials supplied by the Contractor with his first order of piping materials for delivery to the site at the start of the works with the shipment container(s). The cost shall include the entire combined counter flanges, gaskets, bolts, nuts, lubricants and all necessary accessories required for valves and pipes to be ready for installation and shall cover the transport of these items to Yatta Municipality store yard.

The Cost of the spare parts should include the cost for the shipping containers either short or long containers which is needed to protect the material and used as storage for the spare parts. Those shipping containers should be loaded in the yard in Yatta. Therefore; it is required from the Contractor to select shipping containers which are in very good condition or almost new.

## **4 EARTHWORK**

### **4.1 GENERAL**

### **4.2 FOR ANY ITEM NOT COVERED IN THE BELOW SPECIFICATIONS, REFER TO THE GENERAL TECHNICAL SPECIFICATIONS. FILLING AND BACKFILLING**

#### **4.2.1 BACKFILLING AROUND STRUCTURE**

**General:** Surfaces to receive backfill shall be cleared of debris and unsatisfactory materials prior to the placement of the backfill material.

When the top 300 mm of surface to receive backfill has a density less than the required maximum dry density, break up surface, pulverize, moisten and compact such that the required degree of compaction is achieved to form a "compacted sub-grade".

Backfill excavations must be as promptly as the work permits, but not until completion of inspection, testing, approval, and recording of location of underground utilities, as required.

- (i) **Backfilling - Common Fill:** Common Fill may be used as fill against exterior walls of structure as indicated on the Drawings. Materials conforming to the requirements of common backfill (Clause 4.2.3) shall be placed in layers having a maximum thickness of 300 mm measured before compaction, each layer of fill or backfill shall be moistened or aerated and compacted to at least 90 percent of the maximum dry density, or as specified in the Bill of Quantities and drawings which is bigger.

Backfill or fill materials shall not be placed on surfaces that contain excessive moisture, preventing specified degree of compaction.

Material placed in fill areas shall be deposited to the lines and grades shown on the drawings making due allowance for settlement of the material.

No compacting shall be done when the material is too wet either from rain or from excess application of water. At such cases, work shall be suspended until previously placed and new materials have dried sufficiently to permit proper compaction.

- (ii) **Backfilling - Structural Fill:** Structural fill shall be placed in layers having a maximum thickness of 300mm in open areas and 250mm in confined areas including points where conduit and piping join structures, measured before compaction. Each layer shall be moistened or aerated and compacted to at least 95 percent of maximum dry density, or as specified in the Bill of Quantities and drawings which is bigger, by methods specified in these Specifications and approved by the Engineer. The limits of structural fill adjacent to structures shall extend as shown on the Drawings.

Compaction of structural fill in open areas shall consist of fully loaded ten-wheel trucks, a tractor dozer weighing at least 13.5 ton and operated at full speed, a heavy vibratory roller, or any method approved by the Engineer.

Compaction of structural fill in confined areas shall be accomplished by hand operated vibratory equipment or mechanical tampers approved by the Engineer.

#### **4.2.2 BACKFILLING OF TRENCHES**

- (i) **General:** Every section of the pipeline shall be covered as soon as possible after being lowered into trench, but no section of the line shall be covered without express approval of the Engineer. Each section shall be backfilled after the pipe has been placed in its final position on the trench bottom and after all joints and bends and all defects in the pipe coating repaired. Backfilling shall be done carefully to prevent displacement of the pipe or injury to the pipes and their coating. The backfill material shall completely fill the entire space between the pipe and the trench surfaces, without leaving any voids. Care shall be taken that the backfill material does not contain any electrodes, scrap iron, fragments of timber or shrubs, roots, broken skids, tyres, ashes, refuse, oil or soil soaked with oil. On hill sides or sloping ground, furrows or terraces shall be provided across the pipeline trench to direct the flow of rainwater into the natural drain courses and away from the pipeline trench. Where the pipeline crosses natural drainage channels, an opening in the backfill shall be made to avoid interference with normal drainage of the surrounding land. Backfilling shall be done so as not to spoil the road or disrupt its continuity.
- (ii) **Backfilling of Trenches along Asphalted street:** Where the pipes are laid in Asphalted street, the backfilling of trenches shall be done as follows:
- Fine Backfill (surrounding the pipe) shall consist of fine crushed gravel with equivalent sand 50% from any approved source. Gradation as specified in clause (4.2.3). This material shall be placed 150mm below the invert level up to 150mm over the crown of the pipe and for the full width of the trench, or to the depths as indicated on drawings.
  - Laying of warning tape.
  - Crushed gravel (HUMSIEH) shall be spread up to the bottom layer of the compacted base course. Gradation (as specified in Clause 4.2.3).
  - One layer of compacted Base course; thickness of at least 200mm, wetted and compacted to 98% of dry density test as specified in Clause (4.4.2), Table 4.2.
- The compacted base course shall reach the top of the asphalt level. This excess base course will be removed before the asphalt is poured. Backfilled trenches shall be covered with one or two layers of concrete asphalt depending on the thickness of the existing asphalt as specified in section (4.5), as follows:
- If the existing asphalt layer thickness is less or equal 70mm then spread and compact one layer "wearing course" over prim coat.
  - If the existing asphalt layer thickness is more than 70mm then spread and compact two layers; first layer "Binder" of thickness 40-70mm over prim coat and second layer "wearing course" to match the existing asphalt level.
- (iii) **Backfilling of Trenches along Unpaved street:** Where the pipes are laid in Unpaved street, the backfilling of trenches shall be done as follows:
- Fine Backfill (surrounding the pipe) shall consist of fine crushed gravel 50% equivalent sand from any approved source. This material shall be placed 150mm below the invert level up to 150mm over the crown of the pipe and for the full width of the trench, or to the depths as indicated on drawings.
  - Laying of warning tape.
  - Layers of compacted Base course; thickness maximum 200mm each wetted and compacted to 98% of dry density test, to reinstate the level of trench to match with the unpaved street existing level.
- (iv) **Backfilling of Trenches crossing Asphalted street:** Where the pipes are crossing the asphalted street, the backfilling of trenches shall be done as follows:
- Fine Backfill (surrounding the pipe) shall consist of fine crushed gravel with sand equivalent 50% from any approved source. This material shall be placed 150mm below the invert level up to

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150mm over the crown of the pipe and for the full width of the trench, or to the depths as indicated on drawings.

- Laying of warning tape.
- Crushed gravel (HUMSIEH) shall be spread up to the bottom layer of the Base Course material.
- One layer of compacted base course thickness 200mm wetted and compacted to 98% of dry density test as specified in Clause (4.4.2), Table 4.2

The compacted base course shall reach the top of the asphalt level. This excess base course will be removed before the asphalt is poured.

Trenches shall be covered with one or two layers of concrete asphalt after compaction of the base course layer as specified in section (4.5), as follows:

- If the existing asphalt layer thickness is less or equal 70mm then spread and compact one layer "wearing course" over prim coat.
- If the existing asphalt layer thickness is more than 70mm then spread and compact two layers; one layer "Binder" of thickness 40-70mm over prim coat and second layer "wearing course" to match the existing asphalt level.

**(v) Backfilling of Trenches along Natural Ground:** Where the pipes are laid in natural ground, the backfilling of trenches shall be done as follows:

- Fine Backfill (surrounding the pipe) shall consist of fine crushed gravel with sand equivalent 50% from any approved source. This material shall be placed 150mm below the invert level up to 150mm over the crown of the pipe and for the full width of the trench, or to the depths as indicated on drawings.
- Laying of warning tape.
- Layers of selected material ; thickness 200mm each wetted and compacted to 90% of dry density test, to reinstate the level of trench to match with the existing level.

**(vi) Backfilling of Trenches along Sidewalks:** Where the pipes are laid in sidewalks, the backfilling of trenches shall be done as follows:

- Fine Backfill (surrounding the pipe) shall consist of fine crushed gravel with sand equivalent 50% from any approved source. This material shall be placed 150mm below the invert level up to 150mm over the crown of the pipe and for the full width of the trench, or to the depths as indicated on drawings.
- Laying of warning tape.
- Crushed gravel (HUMSIEH) shall be spread up to the bottom layer of the compacted base course. Gradation (as specified in Clause 4.2.3).
- One layer of compacted Base course; thickness 200mm wetted and compacted to 98% of dry density test. as specified in clause (4.4.2), Table 4.2.
- Plain Concrete B200 thickness 150mm or Tile thickness 50mm, mortar 50mm, sand from any approved source comply with ASTM C778; type of finished layer is determined according to the existing materials; plain Concrete or Tile. All work shall be executed according the relevant specifications and matching the existing materials.

### General considerations:

- On trenches with slopes exceeding 20 percent, a 300mm wide, stone partitions shall be built across the trench every 6 meters length. These partitions shall be done constructed over the first stage of the backfill up to the natural ground level, and shall exceed the trench width with 200mm from each side inside the ground. The second backfill stage of the trench between the stone partitions shall be done as specified in each case.

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- Restoring Trench Surface: Where the trench occurs adjacent to paved streets, in shoulders, sidewalks, or in cross-country areas, the Contractor shall thoroughly consolidate the backfill and shall maintain the surface as the work progress. If settlement takes place, he shall immediately deposit additional fill to restore the level of the ground. In some areas it may be necessary to remove excess materials during the clean-up process, so that the ground may be restored to its original level and condition.
- The surface of any driveway or any other area which is disturbed by the trench excavation shall be restored by the Contractor to a condition at least equal to that existing before work began.
- All road surfaces shall be broomed and hose-cleaned immediately after backfilling. Dust control measures shall be employed at all times.

### 4.2.3 MATERIAL USED IN BACKFILL

- (i) **General:** Backfill and fill material shall be selected excavated material, natural or processed mineral soils obtained from off-site sources, or graded crushed stones or gravel. Backfill and fill material shall be free from all organic material, trash, snow, ice, frozen soil, or other objectionable material which can't be properly compacted. Soft, wet, plastic soils which may be expensive, clay soils having a natural in-place water content in excess of 30 percent, soil containing more than 5 percent (by weight) fibrous organic material, and soil having a plasticity index greater than 30 shall be considered unsuitable for use as backfill and fill material. Backfill and fill material shall have a maximum of one percent expansion when testing is performed on a sample remoulded to 95 percent of maximum dry density (as per ASTM D698) at a two percent below optimum moisture content under a 490kg/m<sup>2</sup> surcharge. Backfill material shall be placed as specified in clause 4.2.1.
- (ii) **Common Backfill Material:** Common Backfill or fill material shall not contain granite blocks, broken concrete, masonry rubble, asphalt pavement, or any material larger than 150mm in any dimension provided that this material is not more than 25 percent of the backfill or fill material. Common Fill shall have physical properties, as approved by the Engineer, such that it can be readily spread and compacted as specified in clause 4.2.1 .
- (iii) **Selected Backfill Material:** Selected backfill and fill material shall conform to the requirements of common backfill except that the selected backfill material shall not contain any materials larger than 50mm in its largest dimension provided that this material is not more than 20 percent of the Backfill or fill material.
- (iv) **Structural Fill:** Structural fill shall be gravel, sandy gravel, or gravely sand. Material shall have a plasticity index of less than 15 and shall conform to the gradation limits shown in Table 4.1 below:

**Table 4.1: Structural Fill Sieve Analysis**

Sieve Size	Percent Finer by Weight
100 mm	100
50 mm	85-100
6.35 mm	Less than 70
No. 200	–Less than 5

Structural fill shall be placed as specified in Clause 4.3.2.

- (v) **Crushed Stones:** Crushed stones shall be sound, durable stone, angular in shape, and free of foreign material, structural defects and chemical decay. Crushed stones shall be of a maximum dimension of 50 mm and in a minimum of 12 mm measured in any direction.
- (vi) **Fine crushed gravel** with sand equivalent 50%: Shall be from approved source; sound, from durable stone, free from any foreign materials and structural defects. Also it shall conform to the ASTM Standards. The following table defines the passing/NOT passing sieve opening:

Passing sieve opening	NOT passing sieve opening
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- |  |     |     |
|--|-----|-----|
|  | 7mm | 3mm |
|--|-----|-----|
- (vii) **Crushed gravel (HUMSIEH)** shall be hard, durable, rounded, or sub-angular particles of proper size and gradation, and shall be free from sand, loam, clay, excess fines, and other deleterious materials. The following table defines the passing/NOT passing sieve opening:

Passing sieve opening 16 mm	NOT passing sieve opening 13mm
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### 4.3 GRANULAR MATERIAL

#### 4.3.1 SCOPE OF WORK

Furnish all labour, materials, equipment and incidentals necessary to obtain materials for filling and backfilling, grading and miscellaneous site work, for the uses shown on the Drawings and as specified herein.

#### 4.3.2 MATERIALS

Refer to General Technical Specifications.

### 4.4 BASE COURSE

#### 4.4.1 DESCRIPTION

This work shall consist of performing all operations in connection with the complete construction of crushed limestone base course to the thickness, lines and grades shown on the plans and cross-section.

#### 4.4.2 MATERIALS

Aggregate material for base shall consist of hard, durable, crushed aggregated retained on sieve No. 4 shall have 80% by weight of at least two fractured faces, be mechanically crushed by approved crushing plant and shall be free from organic matter or other deleterious substances and free from clay balls. Base course aggregate shall conform to the following gradation:

**Table 4.2: Base course aggregate gradation**

AASHTO Sieve	Percent Passing
3"	-
2" (50.800mm)	-
1.5" (38.100mm)	100
1" (25.400mm)	75-100
¾" (19.100mm)	60-90
½" (12.700mm)	45-80
3/8" (9.520mm)	40-70
No.4 (4.760mm)	30-65
No.20 (2.000mm)	20-40
No.40 (0.420mm)	8-20
No.200 (0.075mm)	5-10

The fractions passing the No.200 sieve shall not be greater than 70% of the fractions passing No. 40 sieve.

The aggregate shall conform to the following tests requirements:

**Table 4.3: Aggregate tests requirements**

California Bearing Ratio (4 days soaking)	(ASTMD 1883) 80% Min. at 100% M.D.D. AASHTO T-180)
Los Angeles Abrasion	(AASHTO T-96) 40 maximum
Sand Equivalent	(AASHTO-T-176) 30 minimum
Liquid Limit	(AASHTO T-98) 25 maximum
Plasticity Index	(AASHTO T-90) 2 mim.-6 max.
Flaky and elongated particles	(B.S.S. 812) 25% max. each

The following tests shall also be performed:

- A. To determine the presence of soft materials in the base materials, an abrasion test at two different revolution shall be performed; namely at 100 revolutions and at 500 revolutions. Then the ratio of passing sieve No. 12 will be calculated as follows:

Passing sieve No. 12 after 100 revolutions.

Passing sieve No. 12 after 500 revolutions.

The above ration should not exceed 0.22. If such ratio is more than 0.22, then the material of base shall be rejected.

In the above test, the sample is sieved after 100 revolutions on sieve No. 12 then the same sample is put back into the same apparatus to complete to 500 revolutions and then sieved on sieve No. 12 then the ratio is calculated using the above formula. Sample shall not wash in either stage, unlike the normal abrasion test where sample is washed on sieve No. 12 after the end of test to calculate the normal abrasion percentage.

The soundness (ASTM C88) of course aggregate when tested by sodium sulphate method shall not exceed 12% loss. The soundness of course aggregate when tested by magnesium sulphate shall not exceed 16% loss.

- C. Sieve analysis tests shall be performed on samples of base course aggregate where and as directed by the engineer as follows:

1. Gradation tests shall be performed on samples of base course taken after mixing with water and spreading before compaction and shall comply with Clause 4.4.2 with maximum % passing sieve No. 200 being 10%
2. Gradation tests shall be performed on samples of base course taken after the required compaction and the maximum allowable percentage passing sieve No. 200 shall not exceed by more than 3 with the maximum material passing sieve 200 shall not exceed 13 provided that gradation shall comply with Clause 4.4.2

The thickness of the compacted layer(s) shall be measured and recorded when performing field density test; and sieve analysis test on samples taken from compacted layer in place.

#### **4.4.3 CONSTRUCTION**

Aggregate for base course shall be delivered to the roadbed or other places as uniform mixtures and shall be spread in layers or windows. Segregation shall be avoided and the base shall be free from pockets of course or fine materials.

Where the required thickness is 20 cm or less the base material shall be spread and compacted in one layer. Where the required thickness is more than 20cm the base material shall be spread and compacted in 2 or more layers of approximately equal thickness, and the maximum thickness shall not exceed 20cm. The base course shall be spread by graders or other approved mechanical method, watered shaped, and compacted to the required grade and cross-section. The finished surface of the base course shall not vary at any point more than 1 cm above or blow the grade established by the Engineer. In addition to level checking, longitudinally the surface shall be checked with a straight edge of 4 meter long, irregularities in this direction shall not vary more than 1 cm. A minimum of 12 levels of the base every 100m shall be taken and if 3 or more of these levels exceed the tolerance given then the Contractor shall regard the entire 100m length. If less than 3 of the levels exceed the tolerance then the Contractor shall make good these points. The aggregate base shall be compacted to not less than 100% of the maximum density determined in accordance with the latest modified AASHTO T-180-D.

The base course shall be maintained in a condition satisfactory to receive and subsequent base or surfacing material. Aggregate base course which does not conform to the above requirement shall be reshaped or reworked, watered and thoroughly re-compacted to conform to the specified requirements.

## **4.5 BITUMINOUS PAVING COURSES**

### **4.5.1 DESCRIPTION**

This work shall consist of the construction of one or some of the following described asphaltic concrete courses:

- Bituminous Base Course
- Bituminous Levelling Course
- Bituminous Binder Course
- Bituminous Wearing Course

### **4.5.2 MATERIALS**

#### **4.5.2.1 MINERAL AGGREGATES**

Mineral aggregates for "Bituminous Paving Course" shall consist of course aggregates, fine aggregates and filler material. The aggregate shall not contain serpentine olivine particles and a petro graphic examination shall be carried out before delivering material on site. Mineral aggregates shall be tested also in accordance with ASTM C 294 and ASTM C 295. Furthermore the following requirements shall be complied with:

- a. Course aggregate, which is the material retained on an AASHTO No. 4 sieve, shall consist of crushed rock or crushed gravel. It shall be clean, hard, tough, durable and sound, and shall be of uniform quality and free from decomposed stone, organic matter, shale, clay, lumps and other deleterious substances.
- b. The flakiness and the elongation index for each stockpile of course aggregate when tested in accordance with BS 812 shall not exceed 30% for base course and binder courses and 25% for wearing course.
- c. Crushed gravel for use as course aggregate shall consist of the product obtained by crushing material that has first been screened in such a manner that not less than ninety (90) percent of the material to be crushed is retained on an AASHTO 3/8-inch sieve.
- d. The amount of crushing of gravel shall be regulated so that at least ninety (90) percent by weight of the material retained on an AASHTO No. 4 sieve shall consist of pieces with at least two (2) mechanically fractured faces.
- e. The Course Aggregate shall have Water Absorption not more than 2% when tested in accordance with B.S. 812.

Furthermore:

Los Angeles Abrasion: Course aggregate shall have a percentage of wear at the Los Angeles test of not more than 30 as determined by AASHTO T 96 according to the size of tested aggregates.

- 1) Crushing Value: Course aggregate shall have percentage of Crushing Value of not more than 25 as determined by BS 812 - Part 3: 1975.
- 2) Soundness Loss: Course aggregate shall have a percentage of Soundness Loss (sodium and magnesium sulphate) of not more than 10% as determined by AASHTO T 104 according to the size of the tested aggregates.
- 3) Fine aggregates shall consist of that portion of the total aggregate that passes an AASHTO No. 4 sieve. At least ninety (90) percent by weight, of the material passing the AASHTO No. 4 sieve and retained on the AASHTO No. 8 sieve, shall consist of pieces having at least two (2) mechanical fractured face. Should natural material passing the AASHTO No. 4 sieve be included in the mixture, this material shall be fed to the dryer as a separate aggregate and the amount used shall be so limited that the mixture of fine aggregates will contain not less than twenty five (25) percent by weight of the crushed aggregates. In no case shall rounded wind/blown sand be permitted to be used. Maximum value of Water Absorption shall be 2% when tested in accordance with BS 812.

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4) When the combined grading of the course and fine aggregates is deficient in material passing the AASHTO No. 200 sieve, mineral filler shall be added as approved by the Engineer which shall conform to the requirements of AASHTO M 17.

5) The combined mineral aggregate shall meet the following physical requirements:

Specific Gravity 2.55 gr/c.c. minimum

Sand Equivalent (AASHTO T 176)  
Determined after all processing  
Except for the addition of  
Asphalt binder 65 minimum

Plasticity Index (AASHTO T 90) Non plastic

When tested according to AASHTO T 11 and AASHTO T 27, the combined mineral aggregate shall conform to the following grading:

**Table 4.4: Aggregate Grading**

Sieve Sizes (Square Openings)	Total Percent Passing (by weight)		
	Base Course	Binder Course	Wearing Course
1-1/2" (38.1 mm)	100		
1" (25.4 mm)	70 - 100	100	
3/4" (19.0 mm)	62 - 92	80 - 100	100
1/2" (12.7 mm)		65 - 85	80 - 100
3/8" (9.51 mm)	45 - 72	57 - 77	65 - 85
No. 4 (3.76 mm)	30 - 55	40 - 60	46 - 63
No. 10 (2.00 mm)	20 - 40	25 - 45	30 - 50
No. 20 (0.84 mm)	15 - 30	18 - 33	22 - 38
No. 40 (0.42 mm)	10 - 20	13 - 25	15 - 27
No. 80 (0.177 mm)	6 - 15	8 - 17	10 - 20
No. 200 (0.074 mm)	2 - 8	5 - 10	5 - 12

The grading given in Table 4.4 represents the extreme limits which shall determine suitability of aggregate for use from all sources of supply. The aggregate as finally selected for use in the work shall have a grading within the limits designated in Table 4.4, and shall not vary from the low limit on one sieve to the high limit on the adjacent or vice-versa, but shall be uniformly graded from course to fine. The table is based on aggregate of uniform specific gravity, and the percentages passing the various sieves are subject to appropriate correction by the Engineer, when aggregates of varying specific gravities are used.

6) The fine or course aggregate, or composite mixture, shall show no detrimental amount of stripping when tested in accordance with AASHTO T 182. The area coated shall be evaluated not only at 25 degree centigrade but also after the aggregate has been soaked in water at 40 degrees centigrade and 60 degree centigrade. If stripping occurs, the aggregate shall be rejected and an approved method of treatment shall be specified to change the material from a hydrophilic to a hydrophobic state as directed by the Engineer, or an additive shall be used with the bituminous binder only after conducting a trial test and after the approval of the Engineer which use will not relieve the Contractor from his responsibilities.

When necessary to improve the coating of aggregates by bitumen, additives of approved type will be added to the bituminous material in such a percentage as required to obtain satisfactory results in the affinity with bitumen test performed in accordance with ASTM D 1664. The approved additive will be used in accordance with Technical Specifications issued by the manufacturer and approved by the Engineer after appropriate testing.

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- 7) Samples of aggregates shall be supplied by the Contractor at his expense and tests necessary to determine conformance with the requirements specified herein will also be performed by the Contractor at his expense. Materials shall be approved by the Engineer prior to use in the work.

The sources from which the aggregates are to be obtained shall be selected in advance of the time when the materials will be required in the work, and samples of the size required shall be submitted to the Engineer for approval not less than 30 days before such aggregates will be required for use in the work.

Additional samples of aggregates and mineral filler shall be furnished during construction, as required by the Engineer. Unless otherwise directed by the Engineer, AASHTO T 2 shall be used for sampling fine and course aggregates, and AASHTO T 127, paragraph 4.5 and 6 shall be used for sampling mineral filler. Sampling and testing will be observed and supervised by the Engineer when deemed necessary. Only those materials that have been demonstrated by service tests as satisfactory for the intended work will be acceptable.

Approval of sources of supply of aggregate and mineral filler shall be obtained from the Engineer prior to the delivery of the material. Samples of each shall be submitted as directed.

When the Contractor proposes to furnish aggregates from a source not previously approved, aggregates that have no previous satisfactory service record in bituminous pavement construction, or aggregates that are believed to be of doubtful quality, the Engineer will order such tests and other investigations as are necessary to determine whether or not aggregates meeting the requirements of this Specifications can be produced from the proposed sources. Suitable samples from the proposed sources shall be taken under the supervision of the Engineer in accordance with AASHTO T2 and shall be delivered by the Contractor to the location and at the time designated by the Engineer.

The tests to which the aggregate will be subjected shall be carried out by the Contractor at his expense and will include Los Angeles, Absorption, Specific Gravity, Petro graphic Analysis and any other tests that are necessary to determine the suitability of the aggregates for use in producing bituminous mixtures conforming to this Section of the Specifications.

### 4.5.2.2 ASPHALT

Asphalt for "Bituminous Paving Course" shall be Asphalt Cement grade 60-70.

Asphalt Cement grade 60-70 shall conform to the requirements of AASHTO Designation M<sup>20</sup> - 70 (1982).

The asphalt cement shall be prepared by refining crude petroleum with suitable methods and shall be homogeneous, free from water and shall not foam when heated to 175 degree centigrade (347 degree F).

a. **Source of Supply**

A sample of the asphalt cement that the Contractor proposes to use in the work, together with a statement as to its source and properties shall be submitted to and approved by the Engineer at least 45 days before construction begins.

No asphalt cement other than represented by the sample submitted shall be used by the Contractor except with the written consent of the Engineer, and the material used shall comply in all respects with the requirements of the Specifications. Blending of asphalt cement from different refineries will not be permitted.

b. **Asphalt Cement Content**

The percentage of asphalt cement, by weight to be added to the aggregate shall be as prescribed in Table 4.5:

**Table 4.5 : Asphalt Cement Content**

PAVEMENT	ASPHALT CEMENT PERCENT BY WEIGHT OF THE DRY AGGREGAT
Base	3.5 to 4.5
Binder	4.0 to 5.0

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Wearing 4.0 to 5.5

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The exact percentage of asphalt cement to be used shall be fixed by the Engineer on the basis of the Laboratory Tests (Marshall Tests) carried out by the Contractor when submitting the proposed job-mix formula and on the basis of what is stated in the Aggregate Resource Report.

The amount of bitumen absorbed by the Aggregates shall be kept in consideration while fixing the Bitumen content of the Mix Design for the various courses.

**4.5.2.3 JOB MIX**

At least thirty (30) days prior to the date he intends to begin production of plant-mix "Bituminous Paving Courses" mixtures, and after receiving approval of the aggregates from the Engineer and after the delivery on site of the asphalt specified, the Contractor shall make written request for the approved job-mix formula from the Engineer. The job-mix formula will be prepared by the Contractor, under the supervision of the Engineer, in the Project Laboratory.

The job-mix formula shall fix a single definite percentage of aggregate passing each required sieve size, a single definite percentage of asphalt cement to be added to the aggregate, a single definite temperature at which the mixture is to be emptied from the mixer, and single definite temperature at which the mixture is to be delivered to the work.

All mixtures furnished shall conform to the job-mix formula set by the Engineer, within the ranges of tolerances hereinafter specified.

Each day the Engineer shall take as many samples of the materials and mixtures as he considers necessary for checking the required characteristics of the mixtures.

When unsatisfactory results of changed conditions make it necessary, the Engineer may establish a new job mix.

Should a change in a material be encountered or should a change in a source of material be made, a new job-mix formula shall be submitted and approved before the mixture containing the new material is delivered. Job materials will be rejected if they are found not to have the characteristics required by the established job-mix formula.

All mixtures furnished shall conform to the job-mix set by the Engineer, within the ranges of tolerances specified in Table 4.6.

**Table 4.6: Job Mixture Tolerances**

JOB MATERIAL	TOLERANCE
Aggregate passing No.4 sieve or larger	±4%
Aggregate passing No.8 sieve and Retained at 200 sieves	±2%
Aggregates passing No. 200 sieve	± 1%
Asphalt Cement	±0.25%
Temperature of mixing and placing:	± 10 degree C

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The Bituminous Paving Courses mixture shall have the properties as specified in Table 4.7.

**Table 4.7: Properties of Mixture**

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BITUMINOUS	BITUMINOUS	BITUMINOUS
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PROPERTIES	BASE COURSE	BINDER COURSE	WEARING COURSE
Number of Compaction blows each end of specimen	75	75	75
Stability (Marshall) minimum	900	1300	1500
Flow (Marshall) mm	2-4	2-4	2-4
Stiffness minimum Kg/mm	400	450	450
Percent air voids	4-7	4-7	4-6
Percentage voids in mineral Aggregate, minimum % (V.M.A.)	13	13	14
Percent voids filled with Asphalt cement	60-70	60-70	60-70
Loss of Marshall Stability by Submerging specimens in water At 60 degrees centigrade for Twenty four (24) hours as Compared to stability measured After submersion in water At 60 degree C for twenty (20) minutes.	Max 25%	Max 25%	Max25

The Marshall Test procedure will be used to determine the percentage of liquid asphalt that is to be incorporated into the mixture. The mix formula will also take into consideration the absorption of asphalt into the aggregates. Thus, for calculations for voids, the adjusted bulk specific gravity of the Marshall specimens, adjusted for the portion of asphalt lost by absorption, shall be used.

The properties of bituminous paving course mixtures specified in Table 4.7 shall be obtained by tests on the formula respectively for each pavement course and on samples taken at the spreading plant equipment during the works.

Sampling, coring and testing shall be performed by the Contractor at his expense, under the supervision or as directed by the Engineer.

The assistance of the Engineer in the preparation of the job-mix formula in no way relieves the Contractor of the responsibility of producing a bituminous mixture meeting the requirements of the Specifications.

**4.5.3 EQUIPMENT**

Equipment shall be according to the type and number outlined in the Contractor's detailed Program of work, as approved by the Engineer.

In addition to the above requirements, trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds which have been thinly coated with a minimum amount of paraffin oil, lime solution, or other approved material to prevent the mixture from adhering to the beds. When required by the Engineer, each vehicle shall be equipped with a canvas cover or other suitable material of such size to protect the mixture from the weather.

**4.5.4 CONSTRUCTION REQUIREMENTS**

Rolling equipment shall be self-propelled. The wheels on the rollers shall be equipped with adjustable scrappers and the rollers shall have water tanks and sprinkling apparatus, which shall be used to keep the wheels wet and prevent the surface material from sticking.

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### 4.5.4.1 PREPARATION OF ASPHALT CEMENT

Asphalt cement shall be heated within a temperature of 135 degrees C to 155 degrees C at the time of mixing. All material over heated more than 20 degrees C above the maximum shown shall be considered overheated and shall be rejected until the material can be re-sampled and tested. The reacceptance or rejection will be made on the same requirements as established for the original material. Asphalt cement received from the refinery at temperatures in excess of 155 degrees C but not exceeding 191 degrees, may be used.

### 4.5.4.2 PREPARATION OF MINERAL AGGREGATE

Each aggregate ingredient shall be heated and dried at a temperature between 150 degrees C and 170 degrees C.

Immediately after heating, the aggregate or aggregates shall be screened into at least three (3) sizes and conveyed into separate bins ready for batching and mixing with bituminous material. When the aggregates furnished are of such size and grading that separating into three (3) bins is impractical, the number of required separations may be reduced to two (2) with the approval of the Engineer. The efficiency of the screening operations shall be sufficient to produce, at plant operating capacity, gradations in each of the sizes of heated and dried aggregates which are reasonably uniform and result in production of a mixture complying with the limits specified for the aggregate.

### 4.5.4.3 PREPARATION OF BITUMINOUS MIXTURE

Dried aggregate as specified for bituminous construction and prepared as prescribed above shall be combined in the plant in the proportionate amounts as approved. Asphalt cement shall be introduced into the mixture in the proportionate amount determined by the Engineer.

The initial mixing time will be designated by the Engineer. Mixing time may be increased by the Engineer if additional time is necessary to obtain a homogeneous mixture and satisfactory coating.

On batch plants, timing shall begin at the start of the asphalt introduction into the pug mill.

The length of mixing time for continuous plants will be determined by the following formula or other approved methods:-

$$\text{Mixing time in seconds} = \frac{\text{Pug mill dead capacity in kilos}}{\text{Pug mill output in kilos/second}}$$

The temperature of the asphalt, except for temporary fluctuations, shall not be lower than fourteen (14) degrees C below the temperature of the aggregate at the time the two materials enter the mixer or pug mill.

### 4.5.4.4 SURFACE PREPARATION

- a. When the bituminous mixture is placed on a prepared sub-grade, and whether or not a prime coat is designated on the plans, the sub grade shall be prepared to meet the requirements provided in section 4.4 Base Course.
- b. When the surface is an existing bituminous surface, the surface shall be cleaned of all foreign material and broom free of dust. In addition any loose, broken, or shattered bituminous material along the edges of the existing surface shall be removed, and the exposed sub-grade and sufficient width of the shoulder adjacent to the edge of the existing surface to receive the new bituminous mixture shall be shaped, bladed, compacted and broom to provide a uniform sub-grade for the new surface course.

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The existing bituminous surface, base, or sub-grade shall be removed through broken, shattered, or unstable areas as shown on the plans or designated by the Engineer. The areas shall be excavated to a depth directed by the Engineer, and refilled with bituminous mixture herein described.

- c. Prime Coat - Tack Coat: Prior to the Placing of the mixture, when designated on the plans or directed by the Engineer, a prime coat or tack coat shall be applied to the sub-grade or surface in accordance with ASTM D2399-83 for open and tight surface, however, if not specified in the special technical specification MC -70 will be used.

#### 4.5.4.5 PLACING OF MIXTURE

##### a. General

The bituminous mixture shall be spread and finished to crown and grade by automatically controlled bituminous paver. Bituminous mixture may be spread finished by hand methods only where machine methods are impractical as determined by the Engineer.

The automatically controlled paver shall prepare the bituminous mixture without tearing the surface and shall strike a finish that is smooth, true to cross-section, uniform in density and texture, and free from hollows, transverse corrugations and other irregularities.

The paver shall be operated at a speed which will give the best results for the type of paver being used and which coordinates satisfactorily with the rate of delivery of the mixture to the paver, so as to provide a uniform rate of placement without intermittent operations of the paver.

- 1) All mixed material shall be delivered to the paver in time to permit completion of spreading, finishing and compaction of the mixture during day light hours.
- 2) All bituminous mixtures shall be delivered to the paver at a temperature not less than 135 degrees C. Mixtures delivered to the paver at lower temperatures shall be discarded.
- 3) The longitudinal joints in successive layers shall be offset not less than fifteen (15) centimetres. The width of surface of top course placements shall conform to traffic lane edges as shown on the plans.
- 4) The leading half of roadway paving shall not get ahead of the trailing half of the pavement by more than one average full-day of paving and, in no case, shall the leading half be more than half kilometre ahead of the trailing half without the written permission of the Engineer.
- 5) If the Contractor fails to comply with this requirements, the Engineer may suspend paving on the leading half until such time, as the Contractor shall pave the trailing half to a point approximately even with the leading half.
- 6) Unless otherwise directed by the Engineer, where successive layers are to be placed, the surface of the existing layer shall be swept clean with a power broom, or by other means as approved by the Engineer, and a tack coat applied.
- 7) Bitumen mixtures except on leveling course shall be spread in a placement thickness so that, after rolling the normal thickness of the compacted bituminous material shall be according to drawings or as follows:-

Base Course	:	Min. 6 cm.	Max. 10 cm.
Binder Course	:	Min. 5 cm.	Max. 8 cm.
Wearing Course	:	Min. 4 cm.	Max. 6 cm.

The maximum thickness for layers may be increased when such increase is more adaptable to total pavement thickness and when in the opinion of the Engineer it is not detrimental to placement and rolling conditions.

##### b. Preliminary Survey and Reference String Line

## COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM PARTICULAR TECHNICAL SPECIFICATIONS

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The Contractor shall make the survey required for the reference grade. When the survey is approved by the Engineer, the Contractor shall erect and maintain an approved reference string line and operate the paver to conform to the string line for the initial layer and/or any other layers as directed. Elevation control point stakes for the first layer to bituminous paving course shall be set at a maximum spacing of twenty (20) meters. For subsequent layer, control point shall be set at ten (10) meters maximum spacing. The Contractor shall furnish and maintain an approved mobile string line for all layers not laid with the erected string line. The string line shall be erected parallel to the reference grade, and the bituminous mixture shall be spread at a constant elevation above, below or at the string line elevation as directed.

The use of the automatically controlled bituminous paver, to provide both longitudinal and transverse control, shall include the furnishing and maintaining of a string line, whether it be erected or mobile, by the Contractor. The longitudinal and transverse controls shall operate independent of each other, to the extent that the surface of the bituminous mixture will conform to the string line and will be uniform in cross-section or crown.

The Contractor shall establish the centerline points and shall maintain the location of the points until the completion of the surfacing or as directed. When directed by the Engineer, the Contractor shall erect a string line, to be used as a guide for the finishing machine, in order to maintain a uniform edge alignment. If any other method is proposed by the Contractor, it shall be approved by the Engineer.

### **c. Machine Spreading**

The Contractor shall make a survey of the centerline profile and crown of the existing surface or base and determine or calculate a Reference Grade Line and shall furnish to the Engineer for reference and approval the full values at each profile point necessary to erect the Reference String Line.

On the initial traffic lane paving operation, the asphaltic mixture shall be spread with the bituminous paver to a grade line constant to the Reference String Line.

On the second and subsequent layers, the asphaltic mixture shall be spread as described for the initial layer except that the spreading of the asphalt shall conform to a Mobile String Line.

The Mobile String Line or equivalent shall be used as the reference guide on all paving operations, except when the Reference String Line is used or other provisions are made and approved by the Engineer.

On new construction, where paving starts on fresh earth sub grade, the survey may, If approved by the Engineer, be delayed to the surface of the first layer and the use of the Reference Grade Line may be delayed to the first lay-down operation of the second course.

If the existing surface is one of acceptable centerline grade, as determined by the Engineer from the Contractor's profile survey, the Engineer may permit the use of the mobile String Line for all layers.

The use of the automatically controlled paver may be waived on irregular sections or other sections when approved by the Engineer.

On projects where the Contractor uses an approved manually controlled bituminous paver, the same general placement procedures shall be followed. Thirty days prior to the time the Contractor intends to begin paving, he shall present to the Engineer for approval a placement procedure, incorporating the intent of the procedures outlined above, adapted to the Contractor's approved manually operated bituminous paver. No mixture shall be placed prior to the Engineer's approval of the Contractor's proposed methods and procedures for placing the mixture.

### **d. Levelling Course**

A levelling course, consisting of a layer of bituminous material of variable thickness may be used to eliminate irregularities in existing surface or bases and to vary existing cross-section elements of roadways.

### **Survey**

In areas where levelling courses are required, as determined by the Engineer, the Contractor shall survey the existing surface or base. When the survey is approved, the Engineer will determine and inform the Contractor of the precise locations and thicknesses of levelling course to obtain the smoothest possible riding surface. Upon receipt of the locations and thicknesses from the Engineer, the Contractor shall proceed with the placement of the "Levelling Course" using the same procedure specified in this subparagraph.

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### 4.5.4.6 THICKNESS CORES

Depth of each bituminous paving course shall be measured by sawed sample or cored samples. Spacing of samples shall be as described in this Section.

The Contractor shall furnish and operate an approved saw or core drill for cutting samples from the compacted mixture on the road. The equipment shall be capable of cutting the mixture without shattering the edges of the specimen or otherwise disturbing the density of the specimen.

Sawed samples shall be ten (10) centimetres square nominal) and cored samples shall be ten (10) centimetres in diameter (nominal).

Unless otherwise permitted by the Engineer, cores extracted for thickness measurement shall not be used for density determination, and density samples shall not be for thickness measurements.

The Contractor shall, when necessary, furnish and apply cold water, ice, or other cooling substance to the surface of the pavement to prevent the samples from shattering or disintegrating. The Contractor shall cut samples and fill and compact all test holes at his own expense.

### 4.5.4.7 COMPACTION OF MIXTURES

After spreading and strike-off, and as the mix conditions permit the rolling to be performed without excessive shoving or tearing, the mixture shall be thoroughly and uniformly compacted. Rolling will not be prolonged till cracks appear.

Rollers shall be of the steel wheel and/or pneumatic-tyre and shall be in good condition, capable of reversing without backlash, and shall be operated at speeds slow enough to avoid displacement of the bituminous mixture. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. The use of equipment which results in excessive crushing of the aggregate will not be permitted. A minimum of three (3) rollers, one steel wheel and two pneumatic-tyre types, shall be used with each spreading operation.

Initial or breakdown rolling shall be done by means of either a tandem power steel roller or a pneumatic-tyre roller. Rolling shall begin as soon as the mixture will bear the roller without undue displacement. Rolling shall be longitudinally, beginning at the low side of the spread of material and proceeding toward the high side, overlapping on successive trips by at least half the width of the rear wheels. Alternate trips of the roller shall be of slightly different lengths.

The motion of the roller shall at all times be slow enough to avoid displacement of the mixture. To prevent adhesion of the mixture to the rollers, the wheels of the rollers shall be kept properly moistened with water, but an excess of water will not be permitted.

Final compaction and finish rolling shall be done by means of a tandem power steel roller, unless otherwise designated. When the specified density is not obtained, changes in the size and/or number of rollers shall be made as corrective measures, to satisfy the density requirements.

Rollers shall be operated by competent and experienced roller men and shall be kept in operation continuously if necessary, so that all parts of the pavement will receive substantially equal compaction at the time desired. The Engineer will order the mixing plant to cease operation at any time if proper rolling is not being performed.

The road density requirements shall be equal to or greater than ninety eight (98) percent of the Marshall density of each day's production.

Any mixture that becomes loose, broken, mixed with foreign material, or which is in any way defective in finish or density, or which does not comply in all other respects with the requirements of the Specifications shall be removed, replaced with suitable material, and finished in accordance with the Specifications.

Prior to laying of any of the Bituminous Paving Course, the Contractor shall construct trial lengths not to exceed 100 meters. The materials used in the trials shall be those approved for use and the equipment used shall be that according to the Contractor's approved detailed Program of Work.

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The object of these trials is to determine the adequacy of the Contractor's equipment, the loose depth measurements necessary to result in the specified compacted layer depth, and the relationship between the number of compaction passes and the resulting density of the material.

The Contractor may proceed with any of the Bituminous Paving Courses only after the methods and procedures resin the compaction trial have been approved by the Engineer.

### **4.5.4.8 CONTACT SURFACES**

Contact surfaces of curbing, gutters, manholes, and similar structures shall be painted with a thin uniform coating of asphaltic material approved by the Engineer.

### **4.5.4.9 JOINTS**

Longitudinal joints in asphalt courses shall be offset at least 150 mm in relation to the longitudinal joints of the underlying course.

Longitudinal joints of the final course, whether surface or finishing course, shall be located at the center of a lane or at the joints between two adjacent lanes.

Traverse joints in succeeding layers shall be offset at least 2m. The same will apply when a new pavement is laid in contact to an existing old pavement which will be cut back in steps 2m wide in each of its layers.

Before a surface course is placed in contact with a cold construction joint, the cold material shall be trimmed to a vertical face by cutting the material back for its full depth, exposing a fresh face and the contact surface shall be sprayed or painted with a thin uniform coat of tack coat. After placement and finishing of the new material, the material on both sides of the joint shall be dense and the joint shall be well sealed.

### **4.5.4.10 PROTECTION OF FRESH MIXTURE**

The Contractor shall protect all sections of newly compacted mixture from traffic until they have hardened properly.

### **4.5.4.11 MAINTENANCE OF TRAFFIC**

All construction operations shall be coordinated to result in the least practicable delay of traffic. One-way traffic shall be maintained throughout the area. The Contractor shall provide flagmen, reflectorized warning signs, and barricades.

One flagman shall be stationed immediately ahead of the application of fresh asphalt and one flagman immediately behind the area that is being cured, as directed. Suitable speed limit signs and other signs required shall be displayed and the signs shall be moved forward as the work progresses.

## **4.5.5 SURFACE TOLERANCE**

At final compaction the finished surface of the individual layers shall fall within the following maximum variations, measured with a 3m straightedge laid in any direction.

- Base Course        4 mm
- Binder Course     4 mm
- Wearing Course    3 mm

All lumps and depressions exceeding the specified tolerance shall be corrected by removing the defective work and replacing it with new material as directed by the Engineer.

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### 4.5.6 TOLERANCE IN BITUMINOUS PAVING THICKNESS

The thickness of the bituminous paving courses will be determined by average caliper measurement of cores.

For the purpose of determining the thicknesses of bituminous paving courses, units to be considered separately are defined as three hundred (300) linear metres in each traffic lane. The last unit in each lane shall be three hundred (300) meters plus the fractional part of three hundred (300) metres remaining.

Other areas such as intersections, entrances, crossovers, ramps, etc., will be considered as one unit and the thickness of each unit shall be determined separately. Small irregular unit areas may be included as part of another unit. At such point as the Engineer may select in each unit, one core shall be taken for each seven hundred fifty (750) square meters of bituminous paving course. The thickness of the wearing course shall not vary by more than  $\pm 3$ mm, but thickness of base course or binder course shall not vary by more than +3mm or -10mm provided deficiency is compensated by the subsequent layer. The Engineer's Representative has the power to order the removal of deficient layers and reconstruct at the Contractor's own expense if thicknesses are not within the allowable limits.

### 4.5.7 COMPACTION SAMPLING AND TESTING

Densities herein called "Field Mold Densities" will be determined as the work progresses. The field Mold Density shall be determined in accordance with AASHTO T166.

The briquettes used in this ascertainment shall be made of same material used in construction, taken from samples of freshly-mixed bituminous mixtures at the plant. Reheating of the mixture will not be permitted. Extra sample to ascertain the bitumen content only shall be taken from behind the laying equipment.

The density of the mixture as placed and compacted on the road shall be determined from samples cut from the compacted courses on the road locations specified by the Engineer. Samples shall be obtained in sets of two (2) from the same location on the road.

The frequency of testing shall be one (1) set of samples per traffic lane per five hundred (500) linear meters per layer or a minimum of one (1) set per day for shorter runs, and such additional tests to determine limits of areas deficient in density, or for recheck. The density of these samples will be referred to as "Road Density."

The Contractor shall cut the samples with an approved saw or core drill in the presence of the Engineer. The equipment shall be capable of cutting the mixture

Without shattering the edges of the specimen or otherwise disturbing the density of the specimen. Samples shall be ten (10) centimeters in diameter.

Unless otherwise permitted, samples extracted for thickness measurement shall not be used for density determination and density samples shall not be used for thickness measurements.

The Contractor shall, when necessary furnish and apply cold water, ice or other cooling substance to the surface of the pavement to prevent the samples from shattering or disintegrating. The Contractor shall cut all samples and fill and compact all test holes at his own expense.

### 4.5.8 WEATHER LIMITATIONS

Hot asphaltic mixtures shall be placed only when the air temperature is above four (4) degrees C, and when the weather is not dusty, foggy or rainy and when the existing surface is free from moisture. Asphaltic mixture shall not be placed during sand storm.

### 4.5.9 MINIMUM TEST REQUIREMENTS

- a. Bituminous material: One sample shall be tested for penetration and ring ball test every 40 tons.
- b. Aggregates: One sample for each stockpile every 1,000 m shall be taken and all the required test shall be performed.

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- c. Bituminous mixture: One sample of mixture shall be obtained at least every 200 tons and tested for extraction, grading, density and stability.
- d. Loss of Marshall stability shall be tested at least every 10000 tons.
- e. For thickness cores and for compaction cores refer to the relevant subparagraph of this Section.

### **4.6 ROAD CROSSING**

Where water pipeline is crossing roads, the pipeline shall be protected "by slab stress distribution". A concrete support could be used for altimetry setting if any.

Exceptionally and after approval of the engineer, protective steel sleeve with the pipeline inside could be installed for crossing main roads. Refer to General Technical Specifications for such road crossings.

## **5 CONCRETE AND REINFORCED CONCRETE**

### **5.1 GENERAL**

Refer to General Technical Specifications for the Construction of Concrete Water Tanks.

### **5.2 WATERPROOFING**

#### **5.2.1 PART 1 - GENERAL**

##### **Description**

- a. Work Included:
  - 1. Preparation of surfaces to receive the membranes.
  - 2. Supply and placement of the membranes
  - 3. Seal joints (supply and application).
  - 4. Supply and fixing of protective coverings.
  
- b. Related Work:
  - 1. Drawings and general provisions of Contract, including General and Supplementary Conditions, Bills of Quantities and Specification sections, apply to work of this section.
  - 2. Cast in place concrete.
  - 3. Concrete unit masonry.
  - 4. Sealants.

##### **Submittals**

- a. Product Data: The Contractor shall submit samples of water-proofing materials to be used, along with the manufacturer's instructions for the Engineer's review and approval, prior to commencing the work.
  
- b. Shop Drawings:
  - 1. The Contractor shall submit shop drawings indicating water proofing materials, protective covering, and jointing details to the design professional's review and approval. The shop drawings shall be accompanied by a method statement detailing/ clarifying the method of placing the bituminous waterproofing membranes.
  
  - 2. Indicated jointing details to large scale.
  
- c. Warranty:
  - 1. The Contractor shall submit written warranties in the name of the owner for the membrane material approved by the Engineer.
  
  - 2. The warranty shall provide for making good, within period of five (5) years, at no cost to the owner, failure of waterproofing to resist penetration of water, except where such failures are result of structural failures of building. Hairline cracking due to temperature of shrinkage is not considered as structural failure.

#### **5.2.2 PART 3 – EXECUTION**

##### **Surface Preparation**

The Contractor shall clean and prepare surfaces to receive waterproofing in accordance with manufacturers recommendations subject to obtaining the approval of the Engineer.

## **6 WATER TIGHTNESS TEST FOR CONCRETE WATER TANKS**

Refer to General Technical Specifications for the Construction of Concrete Water Tanks.

Water used for water tightness test should be provided by the contractor and at his own cost.

## **7 WATER TANK DISINFECTION**

Refer to General Technical Specifications for the Construction of Concrete Water Tanks.

Water used for water disinfection should be provided by the contractor and at his own cost.

## **8 FENCES, GATES, PAINTING, LINING, COATING AND MISCELLANEOUS WORKS**

Refer to General Technical Specifications for the Construction of Concrete Water Tanks.

## **9 SUPPLY AND INSTALLATION OF PIPES AND FITTINGS**

### **9.1 GENERAL**

#### **9.1.1 POTABLE WATER CERTIFICATION**

All pipes, coating, and lining materials shall be certified for potable water use and shall contain no ingredients that may migrate into water in amounts that are considered to be toxic or otherwise dangerous for health. The Contractor is prohibited to import or to use any of the "Acryl amide and N-Methyl acryl amide Grouts" or any other toxic or poisonous materials or sub materials used in piping, kinds of concrete or in soil in any kind of usage.

The contractor is required to submit certificates from third party recognized by the governmental tender's doctorate, (Bureau VERITAS, Lloyds, SGS, and WRAS) that the components of the network must not be of any way toxic to the water being conveyed. And can be fully used for the distribution of potable water to a temperature up to 50°C. The Certificates should be submitted for the following materials:

- Cement mortar.
- Bituminous paint.
- Epoxy polyurethane varnish.
- Epoxy powder.
- EPDM Sealing Rings and Rubber Gaskets.
- Lubricating paste.

#### **9.1.2 QUANTITIES OF PIPES, VALVES, FITTINGS AND SPECIALS**

Before ordering the pipes, the Contractor shall make a proper survey of the Pipelines and shall make sure of the necessary lengths of each kind of pipes, adapters, fittings, valves, and specials necessary to complete the works. The Contractor shall have no claims for extra or deficit amounts that he orders based on BOQ.

#### **9.1.3 FITTINGS**

Fittings unless otherwise specified shall be furnished with a type of joint compatible with the pipe system at the supplier's option. Any adapters necessary to joint fittings to the adjacent pipes, even of different materials, shall be provided by the Contractor at no extra cost.

#### **9.1.4 TOXIC MATERIALS**

The Contractor is prohibited to import or to use any of the "Acryl amide and N-Methyl acry lamide Grouts" or any other toxic or poisonous materials or sub materials used in piping, kinds of concrete or in soil in any kind of usage. Any Contractor required to be licensed in writing by the Employer, otherwise, the Contractor shall be subject to legal pursuance

#### **9.1.5 COUNTRY OF ORIGIN OF MATERIALS**

The Contractor shall be specific as to the country of origin and manufacturing firm of the materials he intends to supply under the Contract, and shall submit all relative catalogues to the Engineer. Prior to confirming the import of any materials, the contractor shall obtain the written approval of the Engineer

### **9.1.6 STORAGE OF THE MATERIAL**

The contractor shall be responsible for the storage and well being of all materials purchased under this contract. The contractor shall manage and maintain stock yards that can accommodate all materials purchased and approved by engineer under this contract. The materials shall be stored either in the open or under cover as required by the manufacturer/suppliers instructions.

Stacking of the materials (pipes, fittings, accessories...etc) shall be also as per the recommendations and instructions of the manufacturers, and shall be regularly inspected by the engineer staff and maintained to the engineer's satisfaction

## **9.2 STEEL PIPES**

### **9.2.1 GENERAL**

#### **9.2.1.1 WORK INCLUDED**

This specification applies to the supply, assembly and testing of steel pipes and fittings to be executed by the Contractor unless otherwise required by the specification. The Contractor shall conduct site visits before submitting his bid to identify and satisfy himself of the extent and nature of work involved.

#### **9.2.1.2 SCOPE OF WORKS**

The scope of works includes:

- The supply, assembly and testing of pipes and fittings of all pipelines included in the works.
- The interface and connections with the existing lines.

This Specification does not include the on-line equipment such as gate valves, pressure valves, air vents, washouts, etc. These are described in a subsequent section of the Technical Specifications.

The Contractor shall implement all best devices in order to permit maintenance operation in the chambers (staircase in order to have access...).

Actual location and level of interface with existing pipe/connection point must be verified on site in coordination with the Employer and the Engineer.

#### **9.2.1.3 RELATED WORK**

Works shall be executed in accordance with all other sections of technical specifications and in particular:

- Cathodic protection
- Corrosion protection
- Excavations and backfilling
- Gates, valves and appurtenances

#### **9.2.1.4 STANDARDS AND REGULATIONS**

##### **9.2.1.4.1 Standards for pressure pipes**

Preference shall be given to Palestinian Standards (PS) or ISO Standards (International Standards Organization). Other standards such as EN (European Committee for Standardization/CEN), BS (British Standards Institution/BSI), AFNOR (Association Française de Normalisation), DIN (Deutsche Standards für Normung), ASTM (American Testing and Material Standards), ANSI (American National Standards Institute), ACI (American Concrete Institute), AWWA (American Water Works Association), API (American Petroleum Institute) can only be used either if they are compatible and better than the relevant ISO Standards or when no ISO Standard covers the product, based on the Engineer's satisfaction.

All standards and references shall in any case be deemed to include the latest edition available 28 days before the deadline for submission of Bids.

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All units of weight and measurements shall be based on the Metric System of Weights and Measurements.

- General regulations
  - EN ISO 9001: 2000 – Quality management systems – Requirements.
  - EN 805: 2000 – Water supply – requirements for systems and components outside buildings.
  - BS 6920: Materials used in contact with drinking water, whether within buildings or in the water supply system require testing and approval to show that they will not adversely affect water quality.
  
- Steel pipes and fittings
  - Palestinian Standards: PS 107, PS 141, PS 186, PS 325
  - ISO 559: Steel tubes for water and sewage.
  - ISO 1459: Metallic Coating-Protection Against Corrosion by Hot Dip Galvanizing-Guiding Principles
  - ISO 1461: Metallic Coating-Hot Dip Galvanized Coating on Fabricated Ferrous Products-Requirements
  - ISO 2084: Pipeline flanges for general use - Metric series - Mating dimensions.
  - ISO 2441: Pipeline flanges for general use - Shapes and dimensions of pressure-tight surfaces.
  - ISO 2604-3: Steel products for pressure purposes - Quality requirements - Part 3: Electric resistance and induction-welded tubes (ERW).
  - ISO 2604-6: Steel products for pressure purposes - Quality requirements - Part 6: Submerged arc longitudinally or spirally welded steel tubes (SAW).
  - ISO 3452: Non-destructive testing - Penetrant inspection - General principles.
  - ISO 4200: Plain end steel tubes, welded and seamless - General tables of dimensions and masses per unit length.
  - ISO 5252: Steel tubes - Tolerance systems.
  - ISO 6761: Steel tubes - Preparation of ends of tubes and fittings for welding
  - NF EN ISO 21809-1 to 5: Petroleum and natural gas industries - External coatings for buried and submerged pipelines used in pipeline transportation systems
  - NF EN 10224 (NFA 49150): Pipes and fittings carbon steel for the transport of water and other aqueous liquids.
  - NF EN 10311: Joints for the connection of steel tubes and fittings for the conveyance of water and other aqueous liquids

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- NF EN 10253 -1 to 4: Butt-welding pipe fittings
- NF E 27: Fixing elements (bolts and miscellaneous).
- NF E 29: Fittings for industrial pipes.
- NF EN 10290: Water steel pipes and fittings – External liquid applied polyurethane or polyurethane-modified coating –Buried pipes,
- NF EN 10298: Steel tubes and fittings for onshore and offshore pipelines. Internal lining with cement mortar
- NF EN 10289: Steel tubes and fittings for onshore and offshore pipelines - External liquid applied epoxy and epoxy-modified coatings.
- NF EN 10339: Steel tubes for onshore and offshore water pipelines - Internal liquid applied epoxy linings for corrosion protection
- NF EN 1092: Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated.
- NF EN 287: Qualification test of welders - Fusion welding
- NFA 49701: Steel pipes – Cement mortar lining for pipes and fittings,
- NFA 49709: Steel pipes – liquid epoxy lining for pipes and fittings,
- NFA 49710: Steel pipes – Three layer polyethylene coating,
- NFA 49711: Steel pipes – Three layer polypropylene coating,
- NFP 22470: Welding.
- BS 4515: Specification for welding of steel pipelines on land and offshore. Carbon and carbon manganese steel pipelines
- BS EN 1514: Flanges and their joints. Dimensions of gaskets for PN-designated flanges. Non-metallic flat gaskets with or without inserts
- BS EN 681-1 & -2: Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Vulcanized rubber and thermoplastic elastomers
- ANSI/AWWA C206: Field welding of steel pipes.
- ANSI/AWWA C205: Cement mortar protective lining and coating for steel water pipe. 4 inches and larger-shop applied.
- ANSI/AWWA C203: Coal-tar protective coatings and linings for steel water pipelines. Enamel and tape. Hot-applied.
- ANSI/AWWA C209: Cold-applied tape coatings for the exterior of special sections, connections, and fittings for steel water pipelines.
- ANSI/AWWA C210: Liquid epoxy coating systems for the interior and exterior of steel water pipelines.

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- ANSI/AWWA C213: Fusion-bonded epoxy coating for the interior and exterior of steel water pipelines.
- ANSI/AWWA C214: Tape coating systems for the exterior of steel water pipelines.
- ANSI/AWWA C602: Cement mortar lining of water pipelines. 4 inches and larger in place.
- AWWA 200: Steel water pipes 6 inches and larger.
- BS 534 or AWWA standard C208 Standard fittings
- API 5L: Steel Water Pipe.
- ASTM A 283: "Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality".

### 9.2.1.4.2 Design criteria

- Nature and origin of transported water  
Water to be transported by pipes will be potable water.
- Hydraulic design  
All pressure piping shall be designed for a minimum working pressure of 10 bars unless otherwise specified.  
Where and if the design is made by the Contractor, the following loads and temperature conditions shall, where applicable, be taken into consideration in design calculations:
  - water pressure, outside and inside, including dynamic water pressure and water-hammer effects,
  - possible under-pressure,
  - expansion or contraction forces due to temperature or pressure variations,
  - friction forces.

The water-hammer and dynamic effects on the various parts of the system shall be determined in a manner approved by the Engineer and a sufficient margin shall be allowed for in the calculations to cover all possible inaccuracies. Volume of air pressurized tanks shall be checked by the Contractor.

- Pipeline Construction Design  
When calculating expansion or contraction it shall be assumed that at the site the temperature of the material in the open air varies between 90°C and -10°C, and when permanently in shadow between 45°C and -10°C. The water temperature shall be assumed to vary between 45°C and 5°C unless otherwise specified in the general requirements.

The following conditions and stipulations shall apply:

- The pipework shall, where possible, have enough flexibility to allow for dismantling of part and for the thermal expansions and contractions without utilisation of dismantling and expansion joints.

Steel pipes shall be jointed by welding. The pipework shall, however:

- at least have all the flanges indicated on the drawings,
- be dismountable but with a minimum number of flanged joints.

## COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM PARTICULAR TECHNICAL SPECIFICATIONS

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- Pumps, valves and embedded pipes are to be connected with flanges to the pipes. Additional flanges will be approved if necessary to facilitate the erection.
  - For welded constructions the rules set out in the Document XV-50-56E of the International Institute of Welding shall be considered.
  - Parts subject to wear and tear shall, as far as possible, be replaceable.
  - Anchoring and sliding supports as well as other connected equipment as required, shall be designed and capable to withstand the forces and movements resulting from the actual design of the pipe system.
  - The pipework shall be equipped with a sufficient number of valves for venting and drainage. The longitudinal profile of the pipeline, showing all equipment, established by the Contractor must be approved by Engineer.
- Minimal height of cover  
Refer to General Technical Specifications.
  - Soils characteristics  
Reference is made to geotechnical report in appendix ("Additional information").

### 9.2.1.4.3 Shop inspection and field tests

- Inspection  
The quality of all materials, the process of manufacture shall be subject to inspection and approval by the Engineer or by an independent testing laboratory selected by the Employer. Such inspection shall be made at the place of manufacture and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipes may have been accepted as satisfactory. The cost of the inspection, including transportation and accommodation of the Engineer and the Employer (2 persons minimum) shall be paid directly by the Contractor.
- Shop hydrostatic tests  
Before coating and lining, pipelines with a service pressure higher than 6 bars shall be tested.
- field tests  
The test pressure for steel pipes shall be according to the standards: EN 805 – AWWA M11 - BS CP 2010-2

### 9.2.1.5 SUBMITTALS

#### 9.2.1.5.1 General

In his proposal, the Contractor shall provide and justify for all pipes and fittings all necessary guarantees concerning the nature of the materials used, the quality of execution and implementation, their results of ovalization tests, their stability during operation in normal conditions of use, and the interior and exterior protective linings and coatings on the pipes, as well as all supporting calculation memoranda and characteristics.

#### 9.2.1.5.2 Certificates

The Contractor shall furnish a certified report, in triplicate, of the tests for each material to be utilized in the work. The certifications shall contain the result of chemical and physical tests required by these specifications for the materials. All materials in contact with potable water shall have national or international approval certificates for the use in potable water application and the Contractor shall provide copies of all such approval certificates for inspection by the Engineer. Notably, they shall be proven not to cause organic growth.

#### **9.2.1.5.3 Results of shop inspection**

The results of the tests shall indicate:

- Sample identification numbers.
- Sample origin.
- Sampling date.
- Date of tests.
- Reference of the laboratory undertaking the tests.
- Reference to the standards and/or clauses of the Specifications stipulating the values or characteristics to satisfy.
- Description of the tests with reference to relevant standards and/or to relevant clauses of the Specifications.
- Test results with comparison, if applicable, with the values or characteristics specified.

#### **9.2.1.5.4 Design documents**

The Contractor shall submit detailed working and shop drawings and schedules of all pipe, fittings and appurtenances at least two weeks before installation. Shop drawings shall include but not be limited to the following:

- Lists and schedules of material, linings and coatings,
- Schedules of pipe lengths and thicknesses,
- Details of proposed joints, hardnesses and installation details,
- Calculation notes on abrasion in the particular condition of raw water transportation and taking into account water quality analyses of the transported water,
- Names of suppliers and identification of materials and equipment to be supplied,
- Shop drawings shall show the locations of unions, bends, bolted flanged connections or other appurtenances to permit ready dismantling of piping systems.

The work of this section shall be completely co-ordinated with the work of other sections. The Contractor shall verify at the site, both the dimensions and work of other sections which adjoin his materials. Field measurements shall be taken at the site and incorporated in the shop drawings, with specific notes.

Concrete thrust blocks shall be provided at horizontal and vertical bends, tees, crosses, dead ends and reducers whenever necessary. Concrete shall be placed in accordance with design standards or details shown on the drawings or as directed by the Engineer.

#### **9.2.1.5.5 Marking and protection of pipes and fittings for shipment**

Except where otherwise specified all items shall have received their complete protective coatings before dispatch from the manufacturer's works and shall be additionally protected by approved means for the period of transit, storage and erection, against corrosion and accidental damage.

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For the protection of pipe linings and in particular for protecting cement mortar linings from drying out, protective metal or timber discs shall be fitted over the ends of pipes and fittings. Similar timber protective discs shall be attached to all flanges of pipes and fittings, by means of bolts specifically provided for the purpose and which shall be discarded when the item is incorporated in the Works.

The sleeves and flanges of flexible joints shall be wired together in suitable bundles. The following shall be clearly painted on both the coating of the pipes and fittings and on protective discs:

- (a) Supplier's name
- (b) Contract identification number or name
- (c) Item description
- (d) Pressure category of pipe or fitting and wall thickness of flexible pipe

### 9.2.2 PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

#### 9.2.2.1 MATERIALS AND MANUFACTURING

Steel plates shall be as a minimum equivalent to Grade L 235 of EN 10224 or Grade B of ASTM A 283 "Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality".

Manufacturing of steel pipes shall be in accordance with EN 10224 or API 5L or equivalent. The weld shall be of reasonably uniform width and height for the entire length of the pipe and shall be made by automatic means except that, with approval of the Engineer, manual welding by a qualified procedure and welder may be used.

All longitudinal seams or spiral seams and shop girth seams of pipe shall be butt welded. The maximum allowable number of shop seams shall be one longitudinal seam and three girth seams per length of pipe. The longitudinal seams shall be staggered on opposite sides for adjacent section. No reinforcing ring, plate or saddle shall be provided on the exterior or interior of pipe. The length of tubes shall be twelve (12) meters unless otherwise specified or approved by Engineer.

#### 9.2.2.2 WALL THICKNESS

The minimum of the steel pipe wall, measured before coating and lining shall be as specified in the following table.

STEEL PIPE SCHEDULE (all dimensions in mm)		
Nominal diameter (DN)	External diameter	Minimum Wall Thickness
15	21.3	2.11
20	26.7	2.11
25	33.4	2.11
32	42.2	2.11
40	48.3	2.11
50	60.3	2.11
65	73.0	2.77
80	88.9	2.77
100	114.3	2.77
150	168.3	2.77
200	219.1	3.18
250	273.0	3.96
300	323.8	4.78
400	406.4	5.56
500	508.0	5.56
600	609.6	7.14
800	836.6	8.74
1000	1016.0	10.31
1200	1219.2	12.70
1500	1524.0	15.88

#### 9.2.2.3 EXTERNAL COATING

##### 9.2.2.3.1 Buried pipes and fittings

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## PARTICULAR TECHNICAL SPECIFICATIONS

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The choice of the steel pipeline external coating depends particularly on:

- its mechanical resistance to storage, transportation, handling, laying operations,
- its dielectric insulation resistance,
- its chemical inertia compared the characteristics of soils encountered.

The Contractor will justify this choice by providing analysis and project design data. The external coating shall be of polyurethane or polypropylene coating:

In general, the exterior surface of exposed pipes and fittings to be buried shall have a polyurethane or polypropylene three layer coating, complying with standards NF EN ISO 21809-1 to 5 or NFA 49710 and NFA 49711. The total thickness of primary layer and secondary layer shall be not less than 300 microns. The third layer is by a polyurethane or polypropylene coating applied by extrusion. Its thickness depends of the pipe diameter.

### 9.2.2.3.2 Exposed pipes and fittings

All pipes and fittings which will be exposed to view in the finished work shall be painted in accordance with the applicable relevant specifications.

### 9.2.2.4 INTERNAL LINING

Unless specifically noted otherwise, all steel pipes and fittings shall be mortar lined in accordance with NF EN 10298, NFA 49701 or AWWA C205 and AWWA C602.

The lining system shall be shop applied. They shall consist of the following:

#### 9.2.2.4.1 Epoxy lining

Not applicable.

#### 9.2.2.4.2 Mortar lining

The pipe shall be cement mortar lined in the shop or field to meet the requirements of NF EN 10298, NFA 49701 or AWWA C205. Field mortar lining shall meet the requirements of NF EN 10298, NFA 49701 or AWWA Standard C602. Except where otherwise specified or shown, lining thickness shall be as follows, with a tolerance of plus or minus twenty five (25) per cent:

Nominal Pipe Diameter (mm)	Lining Thickness (mm)
100 - 300	8
300 - 400	10
400 - 600	13
Over 600	19

Cement shall conform to ASTM C150 and shall be type I unless other stated by the Engineer. Aggregate shall conform to ASTM C33.

### 9.2.2.5 COATING AND LINING AT PIPE ENDS

#### 9.2.2.5.1 Bevelled ends

At bevelled ends of pipe and fittings 700 mm and larger in diameter, both shop lining and coating shall have a cutback of 15 cm to facilitate field welding.

At bevelled ends of pipe and fittings 600 mm and smaller in diameter, only the coating shall have a cutback of 15 cm, and lining shall be extended to the pipe ends to facilitate field welding.

All interior and exterior surface left as cutback at bevelled ends shall be given one (1) shop coat specified above.

After field welding, the interior surface left as cutback shall be lined with epoxy system or coal tar epoxy system or mortar specified in the article above and the exterior surface left as cutback shall have a heat-shrinkable corrosion protection sleeve which will be specified hereinafter.

**9.2.2.5.2 Plain-ends**

At all plain-ends below ground specially prepared for flexible joints, only the coating except primer shall have a cutback of required length for replacing the joint. The exterior area which may contact with handling liquid shall have the coating as the pipe lining specified after removing the said primer completely. After setting joints, the remaining area which has only the said primer and the exterior of joints shall be finished with petrolatum corrosion protective tape which will be specified hereinafter. The lining shall be extended to the pipe ends.

At all plain-ends above ground specially prepared for joints, the exterior area which may contact with the handling liquid shall have the same coating as the pipe lining specified after removing primer shop applied completely. After setting joints, the remaining area and the exterior of joints shall be painted in accordance with the relevant applicable specifications. The lining shall be extended to the pipe ends.

**9.2.2.5.3 Flanged ends**

At all flanged ends, no cutback of lining and coating shall be provided. The entire surface of the flange shall be painted with the epoxy system or coal tar epoxy system specified in the article above.

**9.2.2.6 FITTINGS**

**9.2.2.6.1 Flanges**

Flanges shall be made as seamless forgings or cut and fabricated from steel plate. Flanges shall be designed for the maximum pressure of the pipe they are mounted on.

Flanges shall be raised face neck flange or slip-on flange and shall be attached to pipe or fittings by means of single butt-weld. Steel plates flanges having either a raised or flat face may be allowed to be used for pipes or fittings of 300 mm and smaller in diameter. Steel plates flanges shall be attached to pipes or fittings by means of two filler joints.

Dimensions of flanges shall conform to ISO 2084, or EN 1092. Dimensions and thicknesses of flange, nominal diameter 80 mm and smaller shall conform to ISO, EN, JIS, ANSI, DIN, or BS or internationally accepted standards. The working pressure of the flange shall be 10 bars minimum.

The seal bearing surface may be raised, with concentric grooves 8 mm apart and 0.4 mm deep, without rough edges, in order to improve the adherence of the seal and prevent it from slipping.

The sealing surfaces of the flanges shall be coated unless otherwise specified. Careful attention must be paid to the angular position of the flanges.

**9.2.2.6.2 Bends, tees, reducers, etc.**

The fittings shall be shop fabricated and shall be designed to have the same strength as piping. The Contractor shall submit a proposed schedule of sizes and thicknesses to the Engineer approval.

**9.2.2.6.3 Joints for pipes and fittings**

Welded joints shall conform to NF EN 10311, NF EN 10253 or BS 4515 and AWWA C206 or equivalent and have bevelled pipe ends. Screw joints shall conform to ISO 7/1.

**9.2.2.6.4 Flexible couplings**

Flexible couplings shall consist of a sleeve, two rubber sealing gaskets and two flanges or two glands which after tying up shall compress the gaskets against the pipe and the sleeve.

Flexible couplings shall allow the following maximum tolerance for the outside diameter of the pipes to be jointed (Steel pipes):

DN (mm)	Tolerance (mm)
219.1 to 323.9	-1.0, +1.6
355.6 to 1219.2	-1.6, +1.6
1350.8 to 1524.0	-3.2, +1.6

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Flexible couplings shall allow the following angular deflection between the jointed pipes:

DN (mm)	Deflection (degrees)
600 and below	5
800 to 900	4
1000 to 1200	3
1500	2

Materials shall be the following:

- Flanges, sleeve: welded steel.
- Gaskets: Nitrile rubber.
- Bolts: Galvanized steel or cadmium plated steel.

### 9.2.2.6.5 Flange adaptors

Flange adaptors shall consist:

- either of a flanged end, a loose flange and a rubber sealing gasket,
- or of a ring, a gland, a loose flange and a rubber sealing gasket.

After tying up, the gland and/or the loose flange shall compress the sealing gasket against the pipe.

Materials shall be the following:

- Body and flange: Cast iron or welded steel.
- Loose flange: Ductile iron.
- Gasket: Nitrile rubber.
- Bolts: Cadmium plated steel.

### 9.2.2.6.6 Dismantling joints

These joints should enable all valves and other fittings on the pipes to be dismantled and reassembled.

They shall be made of ductile iron or steel, and sized in accordance with the diameter of the pipes and maximum service pressure.

They shall consist of two sleeves sliding into one another and fitted with an assembly flange at each end. Watertightness at the point of sliding shall be guaranteed by a rubber seal compressed by an intermediate companion flange. The maximum stroke shall be at least 50 mm.

The dismantling joint shall be assembled on the pipe and fittings by means of threaded rods.

It shall be of "free" type if the pipe is not submitted to longitudinal stress, and otherwise of "self-abutting" type.

Dismantling joints shall be able to restrained axial thrust forces under the nominal pressure of the pipe, with a minimum of 10 bars.

### 9.2.2.6.7 Gaskets

All gaskets supplied with each flange fitting shall comply with BS EN 1514 and BS EN 681. They shall be of flat type, of the inside bolt circle type, unless specified otherwise. Material shall be styrene butadiene rubber (SBR) unless otherwise instructed by the Engineer and thickness of gasket shall be 3 mm minimum.

Prior to application of gasket, the face of the flanges shall be thoroughly cleaned.

### 9.2.2.6.8 Dielectric insulating seals

All fittings of a different nature shall be mounted between flanges with dielectric insulating seals. These insulating seals shall comply with NF C 26150 and be made of an insulating material such as bakelite. They shall be fixed with appropriate bolts, nuts and washers.

When installed in saturated soils, the dielectric seals will be molded in inert material in order to avoid short-cut above the seals.

#### **9.2.2.6.9 Bolting**

Flange assembly bolts shall be standard hexagon head machine bolts with hexagon nuts, complying with NF EN 1092.

Threads shall conform to ISO 68, "ISO General Purpose Screw Threads-Basic Profile". Material for bolts and nuts shall be steel conforming to ASTM, DIN or BS or other internationally accepted standards, and shall have a minimum yield strength of not less than 225 N/mm<sup>2</sup>.

Steel bolts and nuts shall be galvanized. Bolts and nuts for intermittent or continuous underwater pipe work shall be A131, 304L stainless steel. Bolts and nuts for stainless steel flanges shall be stainless steel and type of stainless steel shall be the same as the flanges.

Bolts in flanged joints shall be tightened alternately on opposite ends of joints diameters, in rotation around the flange and evenly.

The bolts shall not protrude more than 3 mm beyond the nuts. Should the bolts protrude more than 3 mm, the bolt ends shall be machined cut and refinished.

Threads of screws and bolts used on parts subject to vibrations and shocks shall be locked.

#### **9.2.2.7 CHECKING OF FACTORY WELDS**

- **General**

Welds shall be prepared, carried out, checked and repaired in accordance with the specifications of EN and ISO standards.

Welds shall be prepared with hollow chamfers, V-shaped for single-side welds and X-shaped for double-side welds.

A straight root face at the base of the chamfer is only permitted if it is of regular height and small enough not to hamper penetration.

V-shaped welds will normally have chamfers opening outwards.

- **The appearance of all welds must be checked**

All welds must be regular and properly connected to the part. Their width end-to-end must be no more than  $1.8e + 5$  mm, with  $e$  being the thickness of the sheet in the case of a V-shaped chamfer or half its thickness in the case of an X-shaped chamfer.

Average build-up is between the following limits:

$$\left(0,5 + \frac{e}{20}\right) \text{ mm et } \left(2 + \frac{e}{10}\right) \text{ mm}$$

Maximum difference in level is:

$$\left(\frac{e}{20} + 1\right) \text{ mm}$$

The length "a" of an apparent continuous defect (groove or lack of penetration) shall be less than 30 mm, the distance separating two defects less than 3a and the sum of all "a" values over the length of the joint L less than L/10.

- **Control of welds**

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All welds shall be checked by means of a penetrant test as per standard ISO 3452 or by using a standardized procedure for which the supplier is entitled eg radiographic inspection following standard ISO 10893-6.

- **Acceptance or rejection of welds**

Weld defect acceptance criteria shall be determined according to the nature, service conditions and importance of the equipment inspected, and in light of the danger and consequences involved in the event of a burst.

More generally, the criteria shall be derived from the standards in force and specific to each class of equipment.

- **Repairing welds**

Defective welds shall be repaired by eliminating the defective area down to sound metal and repeating the weld. Repaired areas shall be re-inspected.

If the new inspection reveals unacceptable work, an additional inspection shall be carried out on either side of the area in question.

If this new inspection does not reveal any defect leading to rejection of the weld, only the area concerned by the first inspection shall be repaired. If not, a complete inspection shall be performed.

A welded area cannot be repaired more than twice in order to avoid changes in the structure of the metal resulting from repeated heating, unless specified to the contrary.

### 9.2.2.8 PIPE HANGERS, SUPPORTS AND BRACKETS FOR INSIDE STRUCTURES

The pipe shall be rigidly supported, and the Contractor shall furnish and install all metallic hanging and supporting piping.

Hangers and supports shall be of approved standard design where possible and shall be adequate to maintain the supported load in proper position under most severe operating conditions. The minimum working safety factor for pipe shall be 5 based on the ultimate tensile strength of the material.

Pipe hangers and supports shall be designed on the basis of pipe weight and possible thrust effect and maximum support spacing which are tabulated in the following table:

Nominal pipe diameter (mm)	Maximum support spacing	
	Steel pipe (m)	PVC pipe (m)
40 & Smaller	2.0	1.0
50	2.0	1.0
65	2.0	1.5
80	2.0	1.5
100	4.0	1.5
125	4.0	2.0
150	4.0	2.0
200	4.0	2.0
250	4.0	2.0
300	4.0	2.0

All overhead hangers shall be adjustable and supported by threaded hanger rods from inserts in the concrete. Overhead hangers, turnbuckles hanger rods and inserts shall be galvanized steel. Hanger rods shall be machine threaded and rod sizes shall conform to the following table:

Pipe diameter (mm)	Hanger rod diameter (mm)
80 and Smaller	10
100 to 150	12
200 and 250	16
300	19

Where support is from walls or columns, welded steel brackets with U-bolts shall be provided. U-bolt sizes shall conform to the following table:

Pipe diameter (mm)	U-Bolt diameter (mm)
80 and Smaller	10

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100 to 125	12
150 and 300	16

### 9.2.2.9 GALVANIZATION

Non applicable.

### 9.2.2.10 SPECIAL TOOLS AND SPARE PARTS

The Contractor shall specify and supply one set of special tools required for dismantling and maintenance of each pipe or fitting.

The Contractor shall supply all the necessary spare parts recommended by the manufacturers. The list of spare parts shall be submitted to the Engineer's approval.

## 9.2.3 EXECUTION

### 9.2.3.1 DELIVERY, STORAGE AND HANDLING OF PIPES

#### 9.2.3.1.1 Handling of pipes

Pipes of all types must be handled with care. Pipes shall be placed on the ground or laid in trenches gently avoiding rolling them on stones or on rocky ground without first creating a runway using planks.

Any pipe accidentally dropped from any height whatever must be considered as suspect and may only be laid after further inspection. With regard to steel pipes, the coating shall be protected against friction wear by packing straw or other soft material between them. They must rest on planks and not on round timber.

All the above stipulations also apply to connections and fittings.

### 9.2.3.2 SURVEY OF THE PIPELINE ROUTE

The Contractor shall be fully responsible for participating in the discussion and necessary expediting with the authorities concerned to get all the necessary approvals for construction of the pipework. Necessary modifications to the preliminary pipeline routes and alignments shall be subject to the approval of the Engineer and the Employer. Subsequent modifications to piping routes and alignments that are necessary after construction work commences shall be carried out on the ground by the Contractor, subject to the approval of the Engineer. The Contractor shall allow sufficient time for the local authorities concerned to issue notices to the land owners to obtain necessary clearances.

#### 9.2.3.2.1 Conventional Survey

The Contractor shall undertake a survey of the entire pipelines, where the new storage and transmission facilities (if any) will be located prior to the commencement of construction work, and shall provide the Engineer with at least two hard copies and one soft copy of the results of the survey, which shall be in autocad format (dwg) and in the same format as the tender drawings. The survey shall also show the location, dimensions and level of underground existing services or obstructions in the pipeline route and shall conform to the following:

(i) The area proposed to be covered by pipelines routes shall be marked clearly and agreed with Engineer prior to commencement of level surveying. Similarly the length of the interconnecting pipework shall be accurately measured and chainage markers (12 mm diameter steel pegs or similar approved) fixed at 25 m intervals (or at intervals instructed by the Engineer) and clearly marked with the chainage at that point. The piping route thus marked shall be agreed with Engineer prior to commencement of level surveying.

(ii) Using a total station or GPS system (accuracy < 10 mm), ground levels shall be taken at intervals agreed with the Engineer, but generally at 25 m or closer intervals across the entire area and along pipeline route and at significant changes in ground level.

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(iii) Levels shall relate to an approved datum, and permanent benchmarks shall be established, well clear of the proposed reservoir and associated pipework location, at intervals.

(iv) Prior to the survey, the Engineer will supply the Contractor with a digital copy of the tender drawings. The results of the survey shall be presented as a modified form of the formation level and piping layout drawings plotted at 1:200 scale or at a suitable scale agreed with the Engineer.

The Contractor shall carry out the survey in the initial stages preferably during the Contract mobilization period and copies of the results shall be submitted to the Engineer without delay. As a result of the survey, the Contractor shall make proposals, as necessary, for any revisions of the facilities layout if necessary (pumping stations, reservoirs...) and pipe invert levels, location of pipe fittings, chambers (including coordinates) etc. At all times the surveying shall be at least one month ahead of excavation and pipe laying to enable agreement to be reached between the Engineer and the Contractor on the lines, levels and gradients.

### 9.2.3.2 Resistivity Survey

Whilst undertaking the conventional survey of the pipeline route the Contractor shall undertake a resistivity survey in accordance with the requirements of BS 1377 Part 9, Section 5.1. Resistivity measurements shall be carried out at not more than 50 m spacing along the pipe route and at all locations agreed with the Engineer on site. The results of the resistivity survey shall be presented in a tabular report format to be approved by the Engineer. As a minimum, the report should list the following information for each measurement:

- Date and time
- UTM WGS 84 grid reference
- Brief description of location
- Resistivity values at depths of 1.5, 2 and 3 m

The resistivity survey report for each section of pipeline shall be presented to the Engineer at the same time as the conventional survey drawings. The Report shall include advice on the expected seasonal variation of the resistivity and, if the tests are carried out during the dry season, the impact of the increase of water content in the ground following rains and under flowing wadis, on the resistivity. Such variation should be demonstrated through watering of the ground in as many selected locations as are needed to demonstrate the variation.

### 9.2.3.3 CUTTING PIPES

Depending on laying requirements, the Contractor shall be entitled to cut pipes. However, all necessary precautions must be taken to ensure that this is only done in cases of absolute necessity and as infrequently as possible.

Pipes may be cut by any process suited to the material in question and in accordance with the pipe supplier's instructions, so as not to disturb its physical state and obtain a clean cut.

The Contractor shall do his utmost to ensure that the new spigot ends resulting from such operations are smooth and that they produce assemblies that are as reliable as ordinary pipe ends.

### 9.2.3.4 CONNECTIONS BETWEEN DIFFERENT PIPE MATERIALS

Where different types or classes of pipe material are jointed together, the Contractor shall supply special fittings or stepped couplings designed and manufactured to suit the ends of pipes to be jointed. Stepped couplings shall comply with the requirements for detachable flexible couplings and flange adaptors where applicable.

A dielectric joint must be placed between the two pipe materials to avoid dysfunction of the cathodic protection of the steel pipes.

### 9.2.3.5 LAYING PIPES

Pipes shall be laid in accordance with BS 8010 unless otherwise specified herein.

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Pipe interiors shall be inspected at the time of laying and carefully cleared of all foreign bodies that may have entered them. The ends shall be carefully cleaned.

Whenever work is interrupted, pipes being laid shall be blocked with a plug to prevent foreign bodies or animals from entering.

Tubes and connections shall be inspected before being assembled to ensure, in particular, that the outer protective coating and possible inner protective lining is intact or restored to its original condition.

Coatings and linings must be carefully repaired whenever they have been removed or damaged.

The pipeline shall be constructed in lengths with a separate full time gang working on each length. The work on the lengths may proceed concurrently. The programme for pipe laying shall be submitted to and be approved by the Engineer, at the start of the Contract. Any subsequent change in programme shall be submitted to and approved by the Engineer, before work to a different programme is started.

Excavation for the pipeline in any one length shall not at any time proceed more than 1 km beyond the end of a tested, completed and backfilled length of pipeline unless otherwise approved by the Engineer. The exposed joints between test lengths shall be disregarded in the above definition. No metal tools or heavy objects shall be permitted to come into contact with the pipes or fittings.

Externally coated pipe shall be handled at all times with wide non-abrasive canvas, rubber or leather belts or other equipment designed to prevent damage to the coating. The use of chains, wire slings, or any other handling equipment found to be injurious to the coating shall not be permitted. The timbers or skids used to support the coated pipe prior to lowering into the trench shall be properly padded with sufficient bags stuffed with sand or straw for the purpose of protecting the coating. Alternatively, the pipe may be supported alongside the trench on mounds of sand.

Any injury to the protective coating from any cause must be repaired before the pipes are tested. Every precaution shall be taken to prevent foreign material from entering the pipes or fittings. During laying operations, no debris, tools, cloth or other material shall be placed in the pipe. Pipes and fittings shall be lowered into the trench with equipment suitable for the weight of the pipes and fittings, and shall be carefully cleaned before jointing. Pipes shall be laid accurately to the lines and levels shown on the drawings, within a tolerance of + 5 mm.

Pipe alignments shall be straight between bends or curves. Lengths laid to curves shall only be allowed where shown on drawings or in accordance with detailed proposals approved by the Engineer. Where approval is given for flexibly jointed pipes to be laid to curves, the deflection at each joint shall not exceed one degree.

For sharper curves purpose-made bevel adaptors and standard bends shall be provided. Properly painted sight rails shall be supplied and erected, with boning rods of predetermined measurement for the boning in of individual pipes to the correct gradient. The sight rails shall be situated vertically above the line of the pipe or immediately adjacent thereto, and there shall at no time be less than three sight rails in position on each length of pipeline under construction to any one gradient.

The Contractor may submit to the Engineer for his approval an alternative method for the control of pipe laying to the correct levels and alignment. The jointing of pipes shall be made in accordance with the manufacturer's recommendations and as the Engineer may order.

The Contractor shall obtain from the manufacturer all special information regarding the handling of their pipes and the formation of the joints and he will be deemed to have made himself thoroughly conversant with all phases of laying the pipes before submitting his tender.

The Contractor shall provide his supervisory staff with the manufacturer's jointing instructions and shall provide the Engineer with three copies for his use. A "badger" or "bung" about 5 mm smaller than the internal diameter of the pipe shall be kept in the pipe at all times and pulled forward as the work progresses. When pipe laying is not in progress, including overnight, the open ends of the pipeline shall be blanked off with a temporary watertight fitting approved by the Engineer.

The pipe shall be suitably held down so that the pipe does not become buoyant in the event of the trench becoming flooded. To restrict the flow of rain run-off along the trench the Contractor shall plug the trench with backfill material at distances not exceeding 250 m until the pipeline can be filled in. The plugs shall be removed when trench filling is taking place.

The criteria for the level and gradient to which pipes shall be laid are as follows:

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- (i) The cover above the crown of the pipe to ground level is defined in section 1.4.3.4.
- (ii) The upward gradient shall be steeper than 1 in 500 (0.2%) with flow, or steeper than 1 in 250 (0.4%) against the flow.
- (iii) The positions of high and low points shall be determined from the Contractor's detailed route survey and shall be as far apart as ground levels permit.

At anchor blocks the depth of the pipe shall be increased, if necessary, so that the top of the anchor block does not project above ground level.

### 9.2.3.6 FIELD WELDING AND QUALIFICATION OF WELDING PROCEDURES AND WELDERS

#### 9.2.3.6.1 Codes and standards

The latest edition of the following codes and standards shall establish the minimum standards for the work.

- ASME B31.4 Pipeline Transportation Systems for Liquid Hydrocarbons
- API 1104 Welding of Pipelines and Related Facilities
- ASME Section IX Qualification Standard for Welding and Brazing Procedures and Welders Brazers and Welding and Brazing Operators
- EN ISO 9001 Quality management systems – Requirements
- EN 10204 Metallic products - Types of inspection documents
- ASTM A370 Standard Test Methods and Definitions for Mechanical Testing of Steel Products
- ASTM E92 Standard Test Method for Vickers Hardness of Metallic Materials
- ISO 148 Steel; Charpy impact test (V-notch)

#### 9.2.3.6.2 Technical requirements

- Qualification of Welding Procedure Specifications (WPS's)
  - General

All testing equipment and facilities shall be supplied and/or at least one accredited and experienced test laboratory has to be nominated to perform all necessary destructive and non-destructive testing as per requirements of this specification and other referenced standards and specifications.  
The equipment and facilities shall be subject to approval.  
Sufficient notice shall be given before commencement of any procedure qualification and related testing.  
The use of pre-qualified procedures may be permitted based on specific approval.
  - Preliminary Welding Procedure Specification (pWPS)

Preliminary WPS's shall be submitted for review and approval at least two weeks prior to the beginning of the welding procedure qualifications.  
The preliminary WPS's shall be in accordance with the requirements of the applicable standards, i.e. ASME Section IX or API 1104 and this Specification for the entire scope of work, including procedures for repair welding.  
The pWPS shall briefly contain the information as required in the relevant standards.
  - Essential Variables

Unless otherwise specified Essential Variables shall be as per the requirements of the applicable standards. If a change in the welding conditions will affect the notch-toughness properties of a weld than also the Supplementary Essential Variables for the relevant welding process as indicated in ASME Section IX shall be qualified.  
For changes outside the range of the Essential and Supplementary Essential Variables a new WPS/PQR shall be qualified in accordance with the applicable standards and this specification.
  - Grouping of Materials

The applicable welding standards API 1104 and ASME Section IX allow a wide range of materials to be grouped for the qualification of welding procedures. This can be considered sufficient for most applications in pipeline construction.  
However, taking the project specific parameters like operating pressure, stress levels etc., in case of pipeline failure into consideration a qualified, separate procedure shall be prepared for

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cases where materials of considerable different strength, chemical properties, heat treatment conditions etc. shall be welded together.

- **Welding Procedure Qualification (WPQ's)**

All WPQ's shall be performed in accordance to the previously approved pWPS's, which have to be stamped and signed as "APPROVED FOR QUALIFICATION".

The qualification test welds shall be performed simulating production welding and reflecting the specific conditions, like clamping, lifting and lowering etc.

All welding parameters and conditions influencing the essential variables shall be recorded using calibrated equipment. All welding for procedure qualification and for production shall be done using calibrated welding machines.

The quality of the qualification welds shall be determined by non-destructive testing (NDT) and destructive testing as per the applicable standards unless amended by this chapter and the separate NDT chapter.
- **Testing of Qualification Welds**

Preparation of test samples and testing shall be performed at an approved field test laboratory.

The welds shall be subjected to non-destructive and destructive testing as per applicable standards and specifications. NDT procedures shall be identical to those used for the welding procedure tests.

All Qualification Welds shall be subjected to NDT after the completion of welding. Where post-weld heat treatment is necessary, this shall be performed prior to NDT.

NDT shall consist of the following:

  - Visual examination
  - Radiographic testing and/or
  - Ultrasonic testing and/or
  - Magnetic Particle Examination

as applicable to the joint design and the specific requirements.

NDT shall only be performed using the approved equipment and procedures that will be employed for production. NDT of a Qualification weld may serve as a qualification test for NDT procedures.

The NDT acceptance criteria are defined in the applicable standards. Any welds failing to meet the acceptance criteria shall be subjected to destructive testing.

For destructive testing as a minimum all Qualification Welds shall be subjected to Macro Examination, Hardness Test and Fracture Toughness Test as described below, supplemented by further tests required in the applicable standards.

### MACRO EXAMINATION AND HARDNESS TEST

Specimens of the cross section from suitable locations covering the weld and the heat-affected zone shall be prepared for macro examination. The prepared surfaces shall be etched using a suitable etchant to reveal the grain structure.

The sections of the weld taken for macroscopic examination shall be used for hardness testing.

The hardness shall be measured in accordance with ASTM E92 or equivalent standards using a 10 Kg load. The hardness indentations shall be evenly distributed across the base material, the heat affected zone and the weld metal.

The macro sections shall be examined at a magnification of x3 and the macrophotographs of the same magnification showing the hardness indentations included in the PQR.

### CHARPY IMPACT TESTING

Charpy Impact testing in general accordance with ASTM A370, ISO 148 or equivalent standards shall be carried out for butt welds when the nominal pipe wall thickness exceeds 5 millimetres.

One set of three specimens shall be taken, with the notch location at each of the following positions:

- Root weld centre-line
- Root fusion line
- Root fusion line + 3 millimetres

When the wall thickness exceeds 20 millimetres, an additional set of three specimens shall be taken at each of the following positions:

- Cap weld centre line
- Cap fusion line

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- Cap fusion line + 2 and 5 millimetres

Specimens shall, wherever possible, be 10 x 10 millimetres full size. Where these dimensions are not possible, sub-size specimen shall be extracted. The test temperature shall be minimum 0°C or below if specified in the base material standards.

The acceptance criteria of Charpy V-Notch test shall as minimum fulfil the requirements of the base material standard unless otherwise specified.

- Qualification of Repair Welding Procedures

All repair welding shall be performed in accordance with an approved repair welding WPS and shall be executed by qualified welders. The repair welding WPS is separate from the original welding procedure with the addition of the following:

- Method of defect removal
- NDT requirements to determine complete removal of defect

To qualify a repair welding procedure, a production weld shall be produced in accordance with the approved WPS and shall be non destructive tested after completion. If acceptable, a section within the allowable limits has to be removed and re-welded in accordance with the proposed repair procedure. Finally this repair weld has to pass all required tests described in the relevant sections of the applicable standards and this specification.

- Re-Tests

### GENERAL

If the mechanical tests fail for whatever reason, the CONTRACTOR shall immediately investigate the causes of the failure, and take all necessary actions including but not limited to retest and/or re-evaluation of PQR parameters.

If after re-testing as described below the qualification weld finally fails to meet the minimum requirements, a new WPS proposal shall be established and qualification welding and testing repeated.

### TENSILE AND BEND TESTS

If one tensile test or bend specimen does not meet the acceptance criteria, two additional specimens shall be tested and both have to meet the acceptance criteria.

### CHARPY V-NOTCH IMPACT TESTS

If either the specified minimum average value has not been achieved or one specimen is below the specified minimum single value, a re-test of three further specimens shall be made. The location of the re-test specimen shall be as close as possible to the location of the original specimens.

### HARDNESS TESTS

If only one hardness result exceeds the specified maximum then three further impressions shall be made in close proximity to that which failed such that they do not mutually interfere. If all of the further tests are below the specified maximum then the test shall be accepted.

If the test joint finally fails to meet the minimum requirements, a new WPS proposal shall be established and qualification welding and testing repeated

- Procedure Qualification Records (PQR's) and final approval of WPS's

During procedure qualification all the parameters used shall be recorded. After completion of the welding procedure qualification a procedure qualification record shall be compiled, containing the following information:

- Revised WPS based on "as-run" parameters
- Printout or datasheet of the "as-run" parameters and welding details
- Summary of the welding parameters including heat input calculation
- Certificates of base materials
- Certificates of filler materials and other welding consumables
- Calibration certificates of equipment
- Pre-heat treatment Records (as applicable)
- PWHT records (as applicable).
- Visual inspection report
- Results of NDT

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- Results of destructive testing

The final WPS, accompanied by the PQR, shall be submitted for review and approval. Based on satisfactory results the WPS will be stamped and signed as "APPROVED FOR CONSTRUCTION".

- Qualification of welders

- General

Each welder shall be qualified in accordance with the welding procedure qualification requirements for each WPS according to which he will perform welding works on site.

Welders and/or operators who welded the procedure qualification test welds, which have been satisfactory non-destructive and destructive tested, shall be deemed as being qualified.

The limits of welder qualification are the essential variables of the WPS. The use of pre-qualified welders, obtaining qualification, which is covering the range of the qualified WPS's, shall be subject to approval.

Qualification shall be valid for a period of six months unless otherwise stated in the applicable standards. This period may be extended by a further six months when it can be shown by NDT from production welding that the welder has produced satisfactory welds. Therefore a "Welder Performance Record" shall be maintained, showing the number of welds and NDT results for each welder and/or operator.

The Contractor shall perform re-training and re-qualification of welders, if the individual weld repair rate exceeds 5%.

- Welder Identification

A unique identification number shall be assigned to each welder and a welder identification card with the welder's name, photograph, identification number, and WPS's for which the qualification is valid shall be issued for each qualified welder.

Each welder shall have the card or a copy available at work location and shall produce the card to the welding inspector if asked for. Welders performing work without identification card shall be suspended from production welding until such time as the card can be produced and shown. In case a welder terminates his work, the identification number shall not be reassigned to another welder.

- Welding consumables

Filler metal identification, trade name and batch certificates shall be kept and maintained during the entire welding operation.

All batches of welding consumables shall be ordered including Manufacturer's Certification according to EN 10204 type 3.1 or similar to demonstrate that they meet the requirements of classification as per ASME Section II Part C or other applicable standards.

The chemical composition of the deposited weld metal shall be compatible with the used base materials, and shall be selected such that the deposited weld metal exhibits mechanical properties equal to or in excess of the base material, as demonstrated in the welding procedure qualifications. As a guideline for the selection of welding consumables ASME Section II Part C or other applicable standards shall be used. All welding consumables shall be stored and handled in accordance with a written procedure and with the manufacturer's recommendations. The written procedure has to be submitted for approval prior commencement of welding activities.

Any consumables that cannot be properly identified or are damaged or contaminated in any way shall be segregated and removed from the job site.

- Production welding

- Pipe Receipt and identification of pipes for repair

All pipes shall be inspected upon receipt by the Contractor's QC inspector as per the requirements of applicable codes, standards and specifications.

The Engineer shall be advised of all defective pipes that are designated for repair work prior to any repair being undertaken.

Pipe body repair by welding shall not be permitted.

- Pipe Body Repair

A minimum length of cut out shall guarantee the complete removal of the defective area, plus 75 mm on either side of the defect. Preheat before cutting is not required when automatic bevelling machines are used and/or the heat affected area will be removed by other mechanical methods.

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If the ovality of the new pipe end is within the requirements for ovality as per the line pipe specification, and acceptable alignment for welding can be demonstrated the pipe may be re-used.

- **Pipe End Preparation and Inspection**

If the supplied pipe shows any bevel damage or it is required to be repaired as stated in the clause "pipe body repair then the bevel ends of the cut pipe shall be prepared and inspected as stated below. This also applies to pipes, which have been cut to shorter length.

Pipes are to be supplied with bevel design in accordance with the approved welding procedure specification (WPS).

If necessary pipe ends shall be bevelled by machining, grinding or machine thermal cutting.

Fusion faces and the surrounding surfaces within 25 mm of the joints shall be free from heavy scale, moisture, oil, or any other substance that may have a detrimental effect on the weld quality.

If machine gas cut is used, the edges shall be free of slag and the cut surface shall be machined or ground back removing any defects having a negative impact on the subsequent welding process. After grinding the bevelled edges shall be visually and MT examined to ensure freedom from defects.

If the pipe is cut back more than 25 mm from the factory bevel, the pipe end shall also be ultrasonic tested in accordance with original mill standard to ensure that no laminations are present.

- **Alignment and Fit-Up**

As a minimum, the pipe shall be visually inspected for the following, immediately prior to line-up for welding:

Pipe ends are uniform and circular with no indication of flattening or denting

- Pipe bevels are free of nicks and gouges
- The joint design conforms to the welding procedure specification (WPS)
- Cleanliness, the bevel and surrounding area shall be free from contaminants such as oil, grease, oxides etc.

For mainline welding internal line up clamps shall be used. For tie-in welds or situations where welding with internal clamp is not applicable (on steep slopes in mountainous areas etc.) external clamps may be used in accordance with the qualified WPS.

Internal line up clamps shall not be removed until completion of root and hot pass and after lowering the pipe on to supports or trench bottom.

External clamps shall not be removed until as much as feasible but a minimum of 50 % circumference of root pass has been deposited in the uphill direction.

In case of longitudinally or spirally welded pipes, a minimum distance of 10 inches (254 mm) between each longitudinal or spiral weld shall be maintained in lining-up pipes and these weld seams shall be located in the top half of the pipe (120°). Particular relaxations in case of welding pipe to bend or bend-to-bend shall be subject to approval.

All fit up conditions like bevel angle, root gap and misalignment shall be checked by using gauges of recognized commercial quality, such as TWI etc.

The maximum allowable misalignment (high/low) measured at the outside diameter shall be as per API 1104. Offsets greater than this limit, which are due to variations in wall thickness may be either corrected by rotating the pipe or machining or grinding to give a 1:4 taper at the transition, providing the minimum wall thickness is maintained. This applies to both mainline and tie-in welds.

Correction of misalignment should normally be corrected by rotating the pipe.

Heating and strong backs shall not be used for correction of misalignment. Hammering is not permitted except by means of a tool with non-ferrous, soft contact surface, for example bronze.

- **Weather Conditions**

Contractor shall supply welding shelters when using a gas shielded welding process.

No welding shall be performed on wet parts. Therefore, in case ambient conditions should cause condensation on the joints and especially in case the joints are wet, the edges shall be dried by heating with a torch on min. 100 mm at each side of the weld.

In case of wind, rain, low ambient temperature (lower than +10°C), welding operations shall not be carried out without having taken all necessary precautions.

Especially in case of rain, or wind (particularly in presence of sand) special shelters shall be erected to protect welders and joints.

Pre-heating of min. 50°C is required if the ambient temperature of the pipe is below 10°C. If the ambient temperature goes below 0 °C a preheating of 100°C shall be performed.

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- **Preheating and Preheat and Interpass Temperature Control**

Preheating, if necessary, shall be carried out using induction heaters or propane torches. The preheat temperature shall be checked immediately prior to the start of welding, it shall be measured 75 mm from the weld preparation at one point (minimum) in each quadrant. The interpass temperature shall be stated in the WPS and shall not exceed that recorded during procedure qualification. Preheat and interpass temperature measurements are to be performed on the external pipe surface using calibrated digital thermometers or temperature measuring crayons. The minimum preheating temperature for weld repair shall be as stated in the relevant WPS. The minimum preheating temperature for tie-in welds shall be as stated in the relevant WPS.
- **Welding Operations**

Welding shall be performed by qualified welders using qualified welding procedures (WPS's) previously approved by the Engineer. The approved WPS's shall be available at the construction site with the welder and the welding supervisor or the welding inspector. During the welding operations the Contractors welding inspector shall be present at each welding work location or area. He is also responsible for 100% visual inspection of Contractors welding work and has to stamp and sign the visual inspection report on a daily basis. Inspection and Testing shall be done by the Contractor as specified API 1104, and as amended by this or other relevant specifications. All welding shall be limited to the weld joint. Insulated ground leads shall be attached by mechanical pressure or magnetic type clamps only. Contractor shall take necessary precautions to prevent arc burns between the ground clamp and the pipe. All arc burns beside the weld bevel or ground clamp arc burns shall be removed by grinding. Defective area shall be examined by MPI to guarantee the complete removal of defect and by UT to guarantee the compliance with the minimum, the section of pipe shall be removed. A minimum of two welders shall be working on opposite sides of the pipe if pipe dia  $D \geq 323.9$  mm. Number of welders should be per approved WPS. The hot pass shall be commenced immediately after root pass welding within the time limit established in the WPS. Interrupted welding shall be part of the mainline welding qualification. Any field weld started shall be completed by the CONTRACTOR on the same day. If for any reason the weld could not be finished it shall be completed 70 %. The weld shall be wrapped for slow cooling and protected from weather conditions that may impair the quality of the completed weld. Preheat in accordance with the approved WPS, but as a minimum 100°C, shall be applied to complete the weld. The minimum spacing between any two-girth welds shall not be less than 2 meters unless agreed otherwise by the Engineer. There shall be not more than three girth welds on any 8 m of pipeline. This shall not apply to the welding of valves and fittings into the mainline. Where air draughts may develop in the piping during welding operations this shall be avoided by properly plugging one end.
- **Repair Welding**

For pipeline welds all repairs shall be performed in accordance with an approved repair welding procedure (WPS's) and shall be executed by qualified welders. A weld with unacceptable defects shall be repaired only once, a repair of a repair is thus not permitted. If the repair is unacceptable the complete weld and pipe shall be removed. Defects necessitating repair shall be removed by grinding to sound metal and Repair weld grooves shall be visually and magnetic particle inspected prior to rewelding; Repaired areas shall be NDT examined as per original weld with extension of 50 mm beyond both ends. The maximum length of a single repair portion shall be:

  - 30 % of the total weld length, for partial penetration repairs
  - 20 % of the total weld length, for full penetration repairs

No repair weld shall be shorter than 50mm. The total repair length shall not exceed 30 % of the total weld length. Repair welding shall be carried out by matching electrodes with vertical up progression and shall be a minimum of 150 °C preheated as stated in the relevant WPS.
- **Tie in Welding**

Definitions:  
This section covers the welding operation to be carried out on line pipes in the following cases:

  - Connection of long pipeline sections inside or outside of the trench
  - Connection of prefabricated river, railway and road crossings to the mainline

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- Connections to or into the mainline, where free welding shrinkage is restricted (Closing joint on pup pieces etc.)

### PERFORMANCE OF TIE IN WELDING

All tie in welds shall be carried out in accordance with an approved tie in welding procedure and shall be executed by qualified welders.

For the alignment and fit up of tie in joints an external clamp shall be used. The root pass shall be performed in uphill progression. Both welding ends have to be machined or have to have an equivalent preparation in accordance with the tolerances of the WPS. The root pass shall be completed and the hot pass shall follow immediately after. The welding shall not be interrupted until the joint has been completed as per the relevant WPS.

The filling and capping passes may be performed using uphill or downhill progression.

### TRANSITIONS

Transitions details for welding of pipe or components having different wall thickness shall be in accordance with the regulations of the design code and good engineering practice.

If pup pieces are used for transitions they shall have a minimum length of 2 meters and shall be welded to the end of sections.

When Automatic Ultrasonic Testing (AUT) is to be used on welds connecting material of unequal wall thickness (i.e. at crossings) special considerations for transitions are necessary in accordance with the type of equipment to be used.

- Traceability of Welds

Contractor has to ensure full traceability of any welding work. The identification number of the welder for each pass has to be marked on the pipe adjacent to the joint with weatherproof chalk or paint marker. This information shall not be removed until the welds have been visually inspected and non-destructive tested and found acceptable. Contractor has to submit a written procedure for weld traceability, along with a sample form of the pipe book/pipe tracking system for approval.

A Pipe & Weld Book (software-based) shall be maintained, whereby, each pipe and weld shall be uniquely identified to its final position in the pipeline, this includes all works such as double joint, mainline, fabrications, crossings, tie-ins, etc.

Data shall include, but not be limited to, consecutive pipe and weld numbers as-laid, date welded, repaired, or cut-out, NDT type and report numbers, weld accepted dates, and agreed survey locations.

### 9.2.3.6.3 inspection, testing and examination

The Contractor shall operate a Quality Management System in compliance with requirements of ISO 9000 Series. All project materials and welding work shall be inspected and tested in accordance with the requirements of the applicable design codes and as described in detail in this specification.

All welding work shall meet the acceptance criteria for non-destructive testing (NDT) as defined in chapter 3.7.2.1. All procedures for testing and inspection shall be subject to the approval of the Engineer prior to commencement of work.

Measuring and test equipment, as well as qualification, inspection and test personnel, shall be in accordance with the requirements of the applicable Codes and Standards.

The project material and the welding consumables shall be furnished with material test certificates according to the requirements of the applicable Codes and Standards and the relevant project specifications.

### 9.2.3.7 STANDARDS AND ABBREVIATIONS FOR TESTING

#### 9.2.3.7.1 Non destructive testing (NDT)

The latest edition of the following codes and standards shall establish the minimum standards for the NDT work.

- ASME B31.4 Pipeline Transportation Systems for Liquid Hydrocarbons
- API 1104 Welding of Pipelines and Related Facilities
- ASME Section V Non Destructive Examination
- EN ISO 9001 Quality management systems – Requirements

The abbreviations used in this chapter have the following meaning:

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- API American Petroleum Institute
- ASME American Society of Mechanical Engineers
- ASTM American Society for Testing and Materials
- ISO International Organisation for Standardisation
- NDE Non destructive Examination
- MT Magnetic Particle Examination
- RT Radiographic Examination
- UT Ultrasonic Examination
- PT Liquid Penetrant Examination

AUT Automated Ultrasonic Examination

### 9.2.3.7.2 Destructive testing

The latest edition of the following codes and standards shall establish the minimum standards for the DT work.

- ISO 9015 to 9018: Destructive tests on welds in metallic materials

Inspected item	NDT Requirement			
	Visual	UT	RT	MT/PT
Field butt welds (general)	100%	100% (1)		(2)
First 100 joints at the start of production	100%	100% (3)		(2)
In case of change of welders up to the first 50 joints of the new welder	100%	100% (1)		(2)
Field tie-in welds	100%	100%	100%	(2)
Welds for connecting pipes of different wall-thickness	100%	(2)	100%	(2)
Welds enclosed in casings or to be concrete weighted	100%	(2)	100%	(2)
Welds for joining special parts such as bends (mitre bends), tees, reducers, valves, etc.	100%	(2)	100%	(2)
Repaired areas in any welds.	100%	100%	100%	100% (4)
Joint after and before defected joint weld	100%	(2)	100%	(2)
Branch connections and fillet welds	100%	(5)	—	100%
Pipe-cut back area and lamination checks prior to welding attachments or fittings	100%	100%		—
Field bevels	100%	—	—	100% (6)
Following removal of arc strikes and crater cracks	100%	100% (7)	—	100%

Notes:

- (1) examination with either automatic ultrasonic or radiographic inspection according to the selected main examination method. For automatic welding (narrow gap) AUT is the preferred method,
- (2) to interpret doubtful indications if required,
- (3) if AUT is the main examination method, than additional 100% RT will be used for verification/validation purposes of the AUT results. If RT is the main examination method, than only 100% RT will be used for the first 100 joints,
- (4) to ensure defect removal prior re-welding,
- (5) if practical,
- (6) if hot-cutting has been used,
- (7) to verify remaining wall-thickness after grind.

### 9.2.3.8 WORK INSIDE PIPELINES

The Contractor shall provide, operate and maintain adequate systems of access, lighting and ventilation to any part of a pipeline where work is in progress inside the pipes.

### 9.2.3.9 ANCHOR BLOCKS (THRUST BLOCKS)

Bends, tees, tapers, plugs, caps, valves, etc. on ductile iron pipelines shall be well braced against undisturbed soil at the edge of the trench with concrete anchor and thrust blocks. The concrete shall contain 300 kgs of cement

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per cubic meter of concrete and the aggregates well graded and the workmanship shall be in accordance with Concrete Works Specifications.(see section 03300 of bidding documents). The dimensions and steel reinforcement shall be in accordance with the typical sections shown on the drawings or otherwise as directed by the Engineer.

The blocks shall, unless otherwise shown or directed by the Engineer, be so placed that the pipe and fitting joints will be accessible for repair.

Where it is not possible to brace against undisturbed soil, suitable feters shall be arranged as directed by the Engineer.

### **9.2.3.10 CONNECTIONS TO EXISTING PIPELINES**

Studded flange pads shall be provided and shall be compatible with pipework to be connected. When connecting into existing mains the Contractor shall be responsible for:

- Making timely and proper applications to the relevant authorities;
- Exposing the existing pipes to confirm the pipe size and type and the fittings necessary to make the connection;
- Conforming to the requirements of the relevant authorities in making the connection;
- Flushing and re-sterilising the part of the existing system affected by the connection prior to putting that part of the system back into service.
- The Contractor shall submit his plans and schedules for making any such connections to the Engineer for approval. The connections shall be scheduled so as to minimise disruption to the existing system.

### **9.2.3.11 CROSSINGS**

This chapter has to be considered as a general specification describing all types of crossings which may be encountered during construction of the pipeline.

For all crossings of railways, roads, wadis, pipelines, cables, etc. the Contractor has to prepare in addition to the alignment sheets adequate construction drawings, including all levels and design features.

The drawings are subject to approval by the owner of the road, railway, pipeline etc. and by the Engineer.

The methods of crossing and the use of casing pipes that may be described in drawings or in this specification are the requirements of the Engineer. However, the Contractor is obliged to comply with any other and/or additional requirements of the Engineer of the facilities to be crossed and has to include also these requirements in his Contract Price.

Work may not be executed unless the drawing has been approved by the owner of the facility and by the Engineer and the Contractor has obtained the work permit form the owner of the facility.

For crossings with important traffic areas or other special sections, the Engineer may request the Contractor to install pipes with stronger wall thickness and/or to perform a separate hydrostatic pressure test for the mentioned pipeline section.

The list of these special sections and crossings will be agreed during final design stage.

### **9.2.3.12 PIPELINES UNDER EXISTING OR PROJECTED ASPHALTED ROADS**

The Contractor shall programme the works to reduce disruption to road traffic to a minimum, and before any work commences in existing road shall:

- (i) Obtain the full permission and approval of all Authorities concerned serving notices of intent to start work as may be necessary and observing all the local laws and regulations.
- (ii) Submit details of his proposals, and obtain approval from the Engineer. Pipelines shall normally cross roads at right angles. Generally, pipeline crossings under existing roads shall be constructed using trenchless techniques that do not interfere with or damage the road pavement. In exceptional circumstances the excavation of existing road surfaces may be allowed by the authorities, in which case the following requirements shall be followed:

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- The bedding and jointing shall be as specified, but the trench re-filling shall be carried out using granular bedding material and compacted at the sides of the pipes to not less than 95% of the maximum dry density as determined by the compaction test in BS 1377: Part 4 (2.5 kg rammer). Above this a 250 mm layer of Class 20/20 concrete shall be placed to bring the level of the backfilling up to 100 mm below the finished road surface. This method of backfilling shall extend at least 2 m either side of the surfaced road carriageway.
- The replacement of the road surfacing shall be carried out as soon as practicable after backfilling has been completed.
- The roadway shall be reinstated using the form of construction and materials as ordered by the relevant authority. The edges of the trench shall be cut to a uniform line consistent with the varying width of the trench and the agreed trimming allowances.
- Any part of the road wearing course which has been damaged beyond the width of the trench must be cut out and made good.
- The Engineer's prior agreement for such additional work must be obtained before additional payment can be considered, in cases where the damage was beyond the Contractor's control.
- A vertical joint shall be formed between the new work and the existing road surface and shall be painted with hot bitumen, or as approved by the Engineer, and the two layer wearing course stepped 75 mm.

The specifications from Ministry of Transport shall be used for asphalted roads or non-asphalted tracks where future roads pipes are planned. This relates to the characteristics of the backfill and asphalt. The Engineer will determine such areas on site.

#### 9.2.3.13 TESTING PIPES

##### 9.2.3.13.1 Pipe cleaning

All pipelines less than 700 mm diameter shall be cleaned by the passing through of a foam swab before the hydraulic test on completion, unless otherwise agreed by the Engineer. Swabbing shall be carried out successively between adjacent swabbing points. Foam swabs shall comply with the recommendations set out in the British Water Research Association, Technical Inquiry Report TIP 130 of 1966, in particular the following:

- Swab diameter to be pipe diameter + 25%
- Quality:
  - Hard: Where restrictions in the main do not reduce the diameter of the pipeline to less than two thirds of the swab diameter.
  - Soft: Where restrictions in the main are in excess of the above but do not reduce the diameter of the pipeline to less than one half of the swab diameter.

##### 9.2.3.13.2 Preparing the tests

Testing operations on joints and pipes shall be carried out by the Contractor at his own expense in accordance with the Engineer's instructions.

Tests are carried out in conditions that allow the pipe and especially all the joints to be properly examined. In particular, the Contractor shall provide and place all blank plates; thrust blocks supply pipes and any other accessory installations required for carrying out the tests, as stipulated, and all necessary equipment.

##### 9.2.3.13.3 Test methods

Tests shall be carried out in accordance firstly with the British Technical Specifications or with the section 70 of the French General Technical Specifications. After complete assembly, but before concreting or backfilling over joints, the piping systems shall be tested at 1.5 times the maximum working pressure.

The Contractor shall supply water for the test at his own expense and shall submit to the Engineer details of the arrangements he proposes to use. No connections to the pipework which would involve cutting, tapping or otherwise permanently altering the permanent works, will be allowed for the purposes of testing.

The pipework shall be capped or flanged off at each end and before pressure is applied. The blanked off ends and the pipework shall be securely strutted or otherwise held to withstand the test pressure. The Contractor's attention is drawn to the considerable forces which will be exerted on the end anchorages, and the possible movement of non-strutted pipes with flexible joints.

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The pipework shall be filled with water and all air liberated through an air valve at the upper end of the line. The line shall then remain under a moderate pressure (10 m head of water) for a period of 30 minutes before final release of air.

The test pressure shall be applied by means of a pump and the pressure shall be raised steadily until the test pressure is reached at the pump and then maintained by the pump, the rate of leakage being measured. The test pressure shall be measured and shall be not less than 20 m head of water pressure.

The leakage shall not exceed 1.0 litre per 10 mm of nominal diameter of pipe per kilometre of line in 24 hours per 100 m head test pressure, and shall be measured over a period of steady test pressure of not less than 24 hours. There shall also not be any visible leakage at any joint. If the test is not satisfactory the fault shall be located, rectified and the pipework retested until a satisfactory result is obtained. All these operations are at the Contractor's expense.

### **9.2.3.13.4 Compliance and additional tests**

The Contractor shall make good any faulty sealing observed during the tests, by immediately and at his own expense making any repairs whatsoever that the tests have shown to be necessary.

However, he shall not bear the cost of replacing, supplying and placing parts not supplied by him if any weakness is shown to be due to the poor quality of the materials or faulty manufacture. The same is true of the cost of the preliminary investigations if such defects should be confirmed.

Once repairs have been made a new test shall be performed in the same conditions as those described above. However, the costs incurred by such tests shall be borne by the Engineer if repairs have been carried out as a result of a burst or deterioration arising from an intrinsic defect in a part not supplied by the Contractor.

### **9.2.3.13.5 Report**

A report is drawn up jointly by the Engineer and the Contractor for each test.

### **9.2.3.13.6 Safety**

Contractor will make sure that all safety measures are implemented during testing activities. He shall provide the necessary safety equipment, communication equipment, access barriers, etc.

All local and statutory authorities, residents in the vicinity of the pipeline and all personnel shall be notified of the proposed dates of testing and shall be advised of any extension

Contractor shall issue a statement to all persons connected with testing, warning of the hazards of failure under pressure.

Safety signboards both in English and Arabic language shall be posted at appropriate locations during testing. The display shall be as follows: "PIPELINE UNDER PRESSURE – KEEP AWAY".

Areas where test equipment is being used shall be clearly marked and entry of unauthorized persons shall not be permitted.

Before pressurisation the Contractor shall put in place appropriate measures to avoid danger to personnel resulting from pipe failure under test, and any damage, disruption or pollution to land, roads, railways, waterways and any other service or installation along or close to the pipeline route.

No work shall be permitted on sections under test.

The Contractor shall provide patrols to watch special points of hazard during test, in particular road, rail and water crossings and points of public access.

All safety measures shall be described in detail in Contractor's written method statement.

### **9.2.3.14 DISINFECTION OF PIPELINES**

After the lines have been hydraulically tested and before they are put into service, they shall be flushed with clean water to remove all foreign matters.

After flushing the lines shall be disinfected by the use of a solution of sodium hypochlorite or calcium hypochlorite. The solution shall be dosed at a concentration such that free chlorine in the water in the line downstream to the point of introduction of the solution shall not be less than 25 ppm. The line shall be blown-off until a residual chlorine of 10 ppm is obtained at the point of blow-off.

When 10 ppm chlorine residual is obtained the blow-off shall be closed and the chlorinated water shall remain in the line for a minimum period of 24 hours. At the end of this period the water shall be tested. If the chlorine residual at the point of blow-off is at least 2 ppm the test will be satisfactory. The line shall be emptied and flushed with clean water. If the chlorine residual at the point of blow-off is less than 2 ppm, disinfection shall be repeated until the test is satisfactory.

The disinfection of the lines can be done in sections. The process shall obtain the prior approval of the Engineer.

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The Contractor shall provide the clean water, the calcium or sodium hypochlorite and all the necessary equipment, and shall make all connections necessary to carry out the disinfection of the system.

### 9.2.3.15 PIPELINES MARKER TAPE

All pipelines shall be marked with an acid and alkali resistant polyethylene detectable warning tape with a minimum width of 300 mm. The tape shall be blue in colour and clearly marked in black lettering with "CAUTION - WATER MAINS BELOW" with a maximum repeat distance between each text along the tape of not more than 1 m.

The tape shall be placed during backfilling of the pipeline trench at a depth of 500 mm below the finished ground level. The tape shall have a minimum strength of 125 kg/sq.cm in the longitudinal direction and 105 kg/sq.cm transversely. The minimum thickness of the tape shall be 0.5 mm. The metallic conductor shall be aluminium foil having a width of not less than 50 mm and a thickness of not less than 10 microns. The foil shall be totally enclosed within the polyethylene laminate such that the edges of the foil are totally protected against corrosive attack.

The aluminium foil strip shall be detectable from the ground surface using a buried cable locator. The manufacturer of the tape shall provide methods for joining and terminating the tape, to enable a low resistance connection to be made to the aluminium foil. Electrical connection points shall be made at each chamber along the pipeline route. A similar yellow detectable warning tape shall be placed 300 mm above the cable duct, which is to be laid either with the pipeline or on its own. It shall be clearly marked in black lettering with "CAUTION – FIBRE OPTIC CABLE BELOW".

### 9.2.3.16 INSTRUCTION MANUALS

The Contractor shall deliver to the Employer 3 sets of the manufacturer's instruction manuals, in English language, covering each item or each group of items delivered under the Contract.

Each set of Manuals shall be bound into one volume, with a table of contents and an index.

The Instruction Manuals shall be submitted to the Employer when the Goods are delivered to the yards and stores.

#### 9.2.3.16.1 Installation Manual

The Installation Manual shall include all instructions, notices, drawings, diagrams and sketches necessary for installing all the Goods, including wherever necessary the method of connection of the Goods with existing structures or with appurtenant structures to be built for the proper operation of the Goods.

The Installation Manual shall also include all documents (procedures, blank forms, criteria of acceptance, required testing equipment, etc.) to proceed with the field tests during installation and tests on completion.

#### 9.2.3.16.2 Operation and Maintenance Manual

The Operating and Maintenance Manual shall include, as a minimum, the following data for each item :

- Equipment operating procedures.
- Illustrations, assembly drawings, and diagrams required for maintenance
- Recommended preventive maintenance procedure and schedules.
- Parts lists by generic title and identification number.
- Dismantling and re-assembly instructions.
- Name and location of the nearest supplier of spare parts.
- Assembly Shop Drawings.

### 9.2.4 CATHODIC PROTECTION

Cathodic protection of steel pipelines shall be implemented as per relevant standards:

- NF EN ISO 8044: Corrosion of metals and alloys - Basic terms and definitions
- NF EN 12499: Internal cathodic protection of metallic structures

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- NF EN 12068: Cathodic protection. External organic coatings for the corrosion protection of buried or immersed steel pipelines used in conjunction with cathodic protection. Tapes and shrinkable materials.
- NF EN 12954: Cathodic protection of buried or immersed metallic structures - General principles and application for pipelines
- NF EN 13636: Cathodic protection of buried metallic tanks and related piping
- NF EN 13509: Cathodic protection measurement techniques
- NF ISO 15589-1: Petroleum, petrochemical and natural gas industries - Cathodic protection of pipeline systems - Part 1 : on-land pipelines
- DIN EN 16299: Cathodic protection of external surfaces of above ground storage tank bases in contact with soil or foundations
- NF EN 50162: Protection against corrosion by stray current from direct current systems
- IEC 60439: Low-voltage switchgear and control gear assemblies
- IEC 60529: Degrees of protection provided by enclosures (IP Code)
- IEC 60989: Separating transformers, autotransformers, variable transformers and reactors
- IEC 61558: Safety of power transformers
- BS EN 12954: Cathodic protection of buried or immersed metallic structures – General principles and application for pipelines.
- BS EN 13509: Cathodic protection measurement techniques
- API RP 651: Cathodic protection of aboveground petroleum storage tanks
- NACE SP 0388: Impressed current cathodic protection of internal submerged carbon surface of steel water storage tanks
- NACE SP 0575: Internal cathodic protection (CP) system in oil treating vessels

### 9.2.4.1 DESCRIPTION OF THE SYSTEM

The cathodic protection system of steel pipes shall be designed and provided by the manufacturer of steel tubes. It shall be installed by the manufacturer of tubes or under his supervision and responsibility.

The manufacturer shall supply for approval to the Engineer a description of the proposed system, together with all necessary information to justify the design of various components and choices of the equipment.

The soil data presented in appendix are provided for information only. It is the responsibility of the pipe manufacturer or supplier of the cathodic protection system to perform at his own expense the additional investigations and measures if deems necessary.

The design and installation of cathodic protection system shall meet relevant standards.

The system shall be an "impressed current protection" or by sacrificial anodes, depending on the length of pipeline and characteristics of soils.

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The impressed current station shall be preferably installed at the pumping station sites.

The buried anode mass will be dimensioned for a lifespan of at least 30 years.

Potential measuring instruments shall be installed in sufficient numbers along the pipe to allow rigorous monitoring of the operation of the cathodic protection system.

The Contractor shall provide to the Employer a detailed manual of verification and maintenance of the cathodic protection system.

He shall also provide training for two technicians of the Employer on verification and maintenance of the system.

### **9.2.4.2 VERIFICATION AND MAINTENANCE OF THE SYSTEM AFTER TEMPORARY ACCEPTANCE**

The manufacturer of steel tubes or supplier of the cathodic protection system shall implement periodic site visits for checking and maintenance of the system during a period of 5 years from the temporary acceptance.

These services shall form part of the Contract and their costs are deemed included in the prices.

## **9.3 EXISTING MAINS CONNECTION**

Connections shall be made to the existing lines as shown on the Typical Drawings.

The connections shall be made from existing plugged ends or from existing lines to be cut, whether dry or under pressure. The level of any existing line shall always be checked by the Contractor before work is started.

Before attempting any connection to the existing network, the Contractor shall inform the Engineer and the Authority responsible for operating the network and agree on a suitable procedure for the works. The Contractor shall give at least six working days notice to the Engineer and will be required to execute these works so as to cause minimal interference with the normal operation of the network, including night working where necessary. Extension of the Contract Period will not be granted for any delays arising out of the Contractor's failure to follow the agreed procedure.

The Engineer's Representative will issue to the Contractor detailed instructions regarding each interconnection that has to be made to the existing mains. Cutting into the existing main pipe and effecting the interconnection shall only be made in the presence of the Engineer or Employer at the time specified by the Employer. The Contractor shall submit additional shop drawings and a detailed method statement for approval by the Engineer.

Cutting into the existing main pipe and installation of the connecting pipe work shall be carried out efficiently and rapidly so as to reduce to a minimum the interruption of the public water supply. Existing mains shall only be cut using special equipment approved by the Engineer. Under no circumstances shall oxyacetylene or electric arc cutters be used. The cut shall be perpendicular to ensure that the new pipe work shown on the Drawings may be installed. The Contractor shall agree with the Engineer's Representative the length of existing pipe work to be removed. The Contractor shall take every care to avoid any dirt or extraneous material entering existing pipes. The Contractor shall have available at the site of the connection an efficient dewatering pump before commencing any cut into the existing main in order that excavation remains dry at all times and to reduce the risk of dirty or contaminated water entering the existing distribution system. The work shall be carried out in a clean and efficient manner. Sufficient length of hoses shall be provided to dispose the water to safe places.

The Contractor shall provide at the site of the connection sufficient quantities of clean water containing 10 ppm chlorine in solution. Every item of new pipe work to be installed shall be submerged in the chlorine solution for at least 15 minutes immediately before being incorporated into the permanent works. The Employer will in general wish to re commission the pipeline as soon as possible after its installation and will carry out an inspection to detect any evidence of leakage; any remedial work necessary to eliminate leakage shall be carried out by the Contractor. No pipe work shall be covered or backfilled until the Engineer's Representative is satisfied that the interconnection is free from any leakage.

Connecting the existing pipes in any material type with the proposed new or replacing pipes is including all needed fittings between different type of material as instructed by the manufactures of DI and PE pipes and also

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include the earth works (excavating, backfilling, reinstating, etc..) as shown in the drawings and or where needed .No claims or extra payments to these connections is applicable.

### 9.4 EXISTING NETWORK DISCONNECTION

Disconnection of the old network where instructed by the Engineer's Representative under the contract and per Zones as shown in the Drawings shall be carried out by the Contractor. Each disconnected line should be cut and plugged on both sides and not by closing valves.

Temporary isolation valves could be used as mentioned in the BOQ as extra over quantity where needed or instructed by the engineer and should be dismantled and handed over to the NM in good conditions .

### 9.5 TESTING -GENERAL

The Contractor shall provide a sufficient quantity of gauges, pumps, stop ends, pipes and connections and all things necessary and suitable for the pressure testing of all pipes. The Contractor shall also provide all necessary temporary works in connection with the test, and shall remove the same on successful completion of the test. All tests shall be done in the presence of the Engineer's Representative and in accordance with the relevant standards for the pipe material under test the results shall be signed by the Contractor and handed to the Engineer's Representative who shall prepare the necessary test reports.

Should any test fail, the Contractor shall (after repairing and making good any leaks), carry out at his own expense further tests all as described above until such tests meet the requirements contained herein.

The results of the tests, specifying the layout of sections of system, pipes and fittings tested including all relevant data of testing as weather, time, duration, filling time, pressure, etc., shall be produced in the form of a report by the contractor and signed by the contractor and the Engineer's Representative. This report shall not relieve the Contractor of his responsibility for care and maintenance of the system until the date of final acceptance of the completed work.

The contractor shall make the water tests for the isolation of each zone in the contract as in drawings and shall provide all needed and necessary fittings or equipments for these tests. The contractor is give note to the engineer 14 days before doing the test in order to have the employer's approval and shall make all the coordination required with the other contractors (specially for contract no. 4)to make sure that the related pumping works were finished and ready to carry out these zone isolation tests ,If required (for any reason approved by the engineer) ,the contractor may do these tests after finish date of the project and disconnect any pipes out of the boundary of the tested zone as specified in the specifications.

#### A. STEEL PIPE TESTING

Refer to section 9.2 above.

#### B. PIPELINE DISINFECTION

After the completed pipeline has been tested, approved and backfilled, the Contractor shall disinfect the pipeline in the following manner:

After flushing the pipes, the system shall be drained completely, all valves shall be closed carefully and the system filled with a chlorine solution. All pipes, fittings, valves and appurtenances shall be disinfected by the Contractor as specified herein unless otherwise directed by the Engineer's Representative.

The Contractor shall take great care to keep the interior of the pipelines free of dirt and other foreign material. If in the opinion of the Engineer's Representative such material has entered a pipe and will not be removed by flushing, then the Contractor shall clean and swab the interior of the pipe with a five percent hypochlorite disinfecting solution to the satisfaction of the Engineer's Representative.

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Simultaneously with the initial filling of the pipeline, the Contractor shall introduce a continuous feed of chlorine at the point where the pipeline is being filled. The rate of filling the pipeline and the feed rate of the chlorine shall be proportioned so that the initial concentration of the chlorine in the water in the pipeline is between 50 and 100 mg/l. To assure that this concentration is maintained, the chlorine residual shall be measured at blow-off points, combination air valves, or other suitable locations during the filling operation.

The use of liquid chlorine will only be permitted when suitable equipment is available. The equipment shall consist of a solution feed chlorinator together with a booster pump for injecting the chlorine gas-water mixture into the pipeline to be disinfected. Introduction of chlorine gas directly from the supply cylinder will not be allowed.

Table 9.1 shows the amount of chlorine required, if either liquid chlorine (gas at atmospheric pressure) or a one percent chlorine solution is used, to produce a 100 milligram per litre concentration in 100 meters of pipe for disinfection of the various diameters of pipe (figures given for information only):

**Table 9.1: Amount of chlorine required**

DN (mm) Nominal	100% Liquid Chlorine (kg)	1% Chlorine Solution (litres)
400	1.30	130
300	0.75	75
250	0.51	51
200	0.33	33
150	0.18	18
100	0.08	8
80	0.05	5
50	0.02	2

After completion of the disinfection operation for one pipeline section the Contractor may reuse this chlorinated water to disinfect adjacent sections of the pipeline adding additional chlorine as required to produce the specified concentration of chlorine.

The Contractor shall submit a detailed description of the procedure he proposes to use to disinfect the pipelines including a description of all equipment to be used for the Engineer's Representative's approval before starting the disinfection operations.

The chlorinated water shall remain in each section of the pipeline for at least 24 hours and during this period all valves and blow-offs shall be operated in order to ensure that these appurtenances are adequately chlorinated. At the end of the 24-hour period, the water in the pipeline shall contain no less than 25 milligrams chlorine per liter throughout the length of the pipeline. Should the water in the pipeline not have the specified chlorine concentration at the end of the 24-hour period, the Contractor shall repeat the operation as necessary to provide complete disinfection.

### **C. FLUSHING PIPELINES**

All pipelines shall be flushed by the Contractor after all hydrostatic pressure tests and disinfection operations have been performed and accepted by the Engineer's Representative.

After draining the chlorine solution, the pipe system shall be flushed with potable water until the free chlorine content is between 2 mg/l and 4 mg/l.

- all the practice needed to insure the maintenance of all the utilities.

No separate payment will be made to the Contractor for this on the job training. The costs shall be included in the prices bid for the various items of work under this Contract.

## **10 VALVES & CHAMBERS**

### **10.1 GENERAL FOR MATERIAL OF VALVES**

Unless otherwise specified, materials should comply with the following requirements

1. Valves body and measuring devices shall be ductile iron.
2. The material shall conform to EN GJS 400-18 according to EN 1563 and ISO 1083 and EN GJS 400-15, 500-7 or ASTM A216-WCB for pressures mentioned above and in the BOQ.
3. Valve stems shall be 410 or stainless steel according to EN 10088-1 and shall be non-rising for gate valves.
4. Stem nuts shall be made of high tensile brass, or gunmetal.
5. Hand wheels and hand wheel nuts shall be malleable iron or steel
6. All name plates and tags shall be stainless steel or plastic.
7. Stainless steel should be 13% chromium minimum conforming to EN10088-1 or DIN 17440 or ASTM A276 or other equivalent standards.
8. Brass should be high tensile brass conforming to EN 1982 or DIN 17660 or ASTM B62 or other equivalent standards.
9. All coatings and materials in contact with water should be certified as suitable for use in potable water.
10. All the valves with their fittings, joints and accessories shall be designed and produced to withstand without any failure or leakage due to all the forces resulted from the minimum working pressure as shown in the drawings plus 8 bars as surge pressure and appropriate for the hydraulic test pressure.
11. Each valve shall be factory tested individually under pressure of 1.5 P max when it is full open and 1.1 P max when it is closed in accordance with ISO 5208 based on the pressures mentioned above.
12. Valves shall close clockwise, and all valves shall be flanged. Flanges shall comply with ISO 7005-2 or EN 1092-2 or equivalent from other Standards.
13. All valves shall have integrated standard flanged, if not specified in the detail design otherwise. All flanges of valves shall conform and satisfy the requirements of EN 736 1-3 and be in accordance with the required test pressure of EN 764.
14. All valves except the Air Valve and Flap valve shall be with standard face to face flanged. The face-to-face and centre-to-centre dimensions of flanged valves shall comply with EN 558-1 and EN 558-2, respectively.
15. All valve flanges dimensions shall comply with those given in ISO 7005-2 or EN 1092-2 and shall be tight with the flanged pipes, fittings and all coupling joints mentioned other parts.
16. The flanged shall be drilled in accordance with ISO 2531-1998(E), EN 545:2010(E).

All type of valves, strainers, and measuring devices shall be cleaned and shot blasted in accordance with ISO 8501-1 Grade SA 2.5, and protected internally (lining) and externally (coating) with fusion bonded powder epoxy to minimum thickness of 300 microns. In addition to manufacturer's standard exterior finish

### **10.2 GATE VALVES AND WASHOUTS**

Gate valves for nominal diameter from DN 50 mm to DN300 mm according ISO 5996, ISO 7259, EN 1171 and EN 1074-1-2.

Short type valves shall be used where necessary to gain space, for example in concrete chambers. The valves shall be of the double flange type, utilizing the same differential pressure across the gate, of PN 16 with screw less bonnet connection, pressure loaded and pressure sealed with easy assembly and dismantling of functional parts or otherwise with stainless steel connected bonnet.

Valves shall be tested in factory in compliance with ISO5208.

## COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM PARTICULAR TECHNICAL SPECIFICATIONS

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Gate Valves must be but not limited to:

1. Un- capsulated valve for easy and fast maintenance.
2. The body, the bonnet, the yoke, the bush nut and the gate shall be made of ductile iron in accordance with standards mentioned above.
3. Removable EPDM sealing & stainless steel seat to avoid cavitations ware.
4. The gate shall be and completely (fully) covered with EPDM elastomer.
5. The gate sealing in the body shall be ensured by the rubber compression.
6. Gate valves shall be of the resilient seal type,
7. The spindle should be cold stamped including the collar and the thread.
8. The dimension as per ISO 5752 – EN 558 basic series 15 (long) for DN 150 mm and above.
9. The dimension as per ISO 5752 – EN 558 basic series 14 (short) for DN 80 mm and DN 100 mm.
10. Shutter of the valves should be guided from the two ends to avoid vibration.
11. The stem sealing shall be provided by two "O" rings. Seals shall be capable of being replaced with the valve under pressure and in the fully open position.
12. Body and the cover must be fully protected with 250 micron\min, fusion bond high temperature Epoxy coating.
13. Valves shall close clockwise.
14. Marking the valves shall indicate the name of the factory and the relevant standard.

All connecting material and rubber ring gaskets or adaptors shall be provided by the Contractor as necessary to connect the valve with the adjoining pipe material.

Valves with diameter < 150 mm shall be installed in the ground in accordance with the Standard Drawings also shall be buried and shall be supplied with stem nuts coupling, sleeves and extension spindles of 0.5 m and 1.00 m length according to the requirements on site.

Valve spindle shall be of stainless steel. Extension spindles shall be made of hot dip galvanized iron, coupling sleeves of galvanized ductile iron connection pins of C & Ni steel.

Spindles may have to be shortened to suit the particular site requirements. The top of the extension spindle shall be fitted with ductile iron surface box according to DIN 4056 with pre-cast concrete support. The spindle itself shall be protected by a suitable PE guard tube including tube cover. Valves to be installed above ground or in valve boxes shall be provided with hand wheels of mehanite ductile iron. All valves shall be supported by concrete blocks.

Valves with diameter  $\geq 150$  shall be installed in concrete valve chambers according to the Standard Drawings. These valves shall be complete with hand wheels so as to be operable inside the valve chamber. These valves shall additionally be equipped with extension spindles, where needed, and surface boxes, as described above and as shown as a general detail on the Standard Drawings, to allow operation without entering the chamber. The extension spindles are to be connected to the hand wheels by stem unit couplings. The surface box shall be casted into the concrete cover above the spindle. Diameter of hand wheels

DN 250-DN300: 500 mm (minimum)

DN 200: 400 mm

DN 150: 315 mm

One operating key shall be provided for every 10 valves delivered. One extra hand wheel shall be provided for every 50 valves of diameter  $\geq 150$  mm delivered.

### **Washout**

Washout valves shall be installed in concrete valve chambers (washout) according to the Standard Drawings. These valves shall be complete with hand wheels so as to be operable inside the washout chamber. These valves shall additionally be equipped with extension spindles, where needed, and surface boxes, as described above and as shown as a general detail on the Standard Drawings, to allow operation without entering the chamber.

### **10.3 AIR RELEASE VALVE KINETIC, AUTOMATIC AND COMBINATION AIR/VACUUM VALVE**

#### Kinetic Air Release Valves with Large Orifice

This type of valve is used to release air at high flow rates during the filling of the line and to allow air to enter the line at high flow rates during its emptying.

The Kinetic Air Release valve will function when the line is not under pressure. It is designed so that when the line is under pressure (water flowing) the valve will stay closed.

#### Automatic Air Release Valves with Small Orifice

This type of valve is used to release air during water flow, while the system is under pressure. When air bubbles appear in the valve, the ball will drop, causing air to be released. When the water rises again, the ball will be lifted, causing the valve to close

#### Combination air/vacuum (triple function, double orifice)

These Combination air/vacuum valves incorporate an automatic and kinetic air release valve into one unit. Combination air/vacuum valves shall include a small orifice and a large orifice, consisting of:

- One resilient seated large orifice for release and admission of air when filling and emptying
  - One small nipple orifice for release of air accumulated under normal working conditions. It shall be designed to operate under the pressures shown in the BOQ.
1. The triple function air valves shall not have incorporated isolated valve. However, the single air valves shall have incorporated isolated valve.
  2. All air valves shall have integrated flanged inlet drilled according to ISO 7005-2 and EN 1092-2 complying with the pressures mentioned above and shall be fitted with lifting eyes for handling
  3. The dimensions of the flanges shall be suit to tight with the flanges of the gate valves flanges mentioned above.
  4. Air valves should have orifice(s) sized for the operating conditions.
  5. Air Valves should comply with EN 1074-4.
  6. Valves should be suitable for water service and where required should combine the operating features of air release and air re-entry into the system to prevent vacuum and allow system drainage. The air release portion should automatically exhaust entrained air that accumulates in system.
  7. Ductile iron body, cover and flange
  8. Stainless steel ball floats for large and small orifice and trim should be provided to meet the operating conditions.
  9. Valve body should be coated with Epoxy powder Coating of minimum thickness 300 micron.
  10. The valve should automatically operate in order to:
    - a) Positively open under internal pressure lower than the atmospheric pressure, to admit air in bulk during pipeline draining,
    - b) Exhaust air in bulk during pipeline filling and positively close when water fills the body of the valve,
    - c) Exhaust accumulated air under pressure when the pipeline is in operation
  11. The valve body and bonnet should be made of ductile iron.
  12. The ball floats should be made of stainless steel or rubber coated steel.
  13. The nozzle (small orifice of the valve) should be made of brass.
  14. The valve should be flanged. The flange should comply with ISO 7005-2, EN 1092-2 or equivalent from other standards.
  15. The single air valve shall have a built-in stop valve for maintenance

For pipes 150 mm and larger, Combination air/vacuum valves (triple function) shall be supplied with double orifice air valves with both, small and large orifices. Valves shall be of the flanged type and of pressure class PN 16.

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The following types and minimum sizes of air valves (nominal diameter) shall be used:

Pipe DN	Valve
63	Kinetic Air Release Valves DN 50
90	Kinetic Air Release Valves DN 50
125	Kinetic Air Release Valves DN 50
150	Combination air/vacuum valve DN 60
200	Combination air/vacuum valve DN 60
250	Combination air/vacuum valve DN 60
300	Combination air/vacuum valve DN 80

Air valves shall be designed to limit water hammer effects.

### 10.4 PRESSURE REDUCING VALVES

The pressure reducing valve (PRV) shall maintain a constant downstream pressure regardless of the varying inlet pressure. The valve shall be provided with an integrated low flow by-pass. The PRV shall be of the hydraulically operated type with pilot control. All necessary repairs shall be possible without removing the valve from the line. The Material of the counter –nut is to be Bronze type UE7, the cover is Ductile Iron with epoxy coating of 200 microns, the spindle is stainless steel type 18-8, the skirt is steel type A40, The shutter is steel type Xc38, Flange is Steel type A 40, O-ring is Nit rile, Screw is steel, Shutter gasket is polyurethane, Tie bar is Stainless steel type 18-8, Bearing is Bronze type U E 7, Lower spring support is to be Cast iron, Spring is to be steel, Upper spring support is to be Steel type XC 38, nut is bronze type UE7, setpoint screw is stainless steel type. The main PRV shall be equipped with a special spring, insuring to keep the PRV closed, as soon as the inlet pressure is reading a very low minimum of 2 m, in order to keep the pilot system as much as possible filled with water.

The PRV shall be equipped with an automatic venting device, permitting to vent automatically the air trapped in the pilot system, as well as in the main valve, as soon as these ones are coming back under water pressure.

The valve body shall be in Ductile Iron GG 25 for a minimum pressure rating of 16 bars and shall have an epoxy coating both internally and externally. The spring shall be of stainless steel 50 CrV4. Disc guide, seat and cover bearing shall be of stainless steel. The pilot control shall be a direct -acting, adjustable spring loaded diaphragm valve, normally open. The pilot valve shall be in bronze or stainless steel and Pilot System tubes in copper. The pilot valve and the by-pass system shall have stopcocks in the inlet and outlet piping to isolate the valve when necessary and a strainer. Pressure gauges for adjustment of the valves shall be attached to the valve body.

The flanges of the PRV shall be in accordance with DIN 2501 or ISO 2531. The PRV shall be hydrostatically tested at the factory to 25 bars. The range of working pressure shall be as follows:

- upstream side -up to 8 bar
- downstream side -2 bar

The valve shall maintain the downstream pressure within a range of  $\pm 10\%$  with respect to the set pressure.

The Contractor however shall make sure that the size of the valve is correct for the required flow.

Valves shall be installed strictly in accordance with the manufacturer's recommendation. The installation shall include, but not limited to, isolation valves on the upstream and downstream side, by-pass line with isolation valve and pressure gauges including pressure sensors (for connection to a data logger) upstream and downstream of the isolation valve, upstream strainer in main line, pressure relief valve and air release valve on the downstream side all as shown on the standard drawings

### 10.5 PRESSURE SUSTAINING VALVES

## COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM PARTICULAR TECHNICAL SPECIFICATIONS

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The pressure sustaining valve (PSV) shall maintain a constant upstream pressure regardless of the varying outlet pressure. The valve shall be provided with an integrated low flow by-pass. The PSV shall be of the hydraulically operated type with pilot control. All necessary repairs shall be possible without removing the valve from the line. The Material of the counter –nut is to be Bronze type UE7, the cover is Ductile Iron with epoxy coating of 200 microns, the spindle is stainless steel type 18-8, the skirt is steel type A40, the shutter is steel type Xc38, Flange is Steel type A 40, O-ring is Nit rile, Screw is steel, Shutter gasket is polyurethane, Tie bar is Stainless steel type 18-8, Bearing is Bronze type U E 7, Lower spring support is to be Cast iron, Spring is to be steel, Upper spring support is to be Steel type XC 38, nut is bronze type UE7, setpoint screw is stainless steel type. The main PSV shall be equipped with a special spring, insuring to keep the PSV closed, as soon as the inlet pressure is reading a very low minimum of 2 m, in order to keep the pilot system as much as possible filled with water.

The PSV shall be equipped with an automatic venting device, permitting to vent automatically the air trapped in the pilot system, as well as in the main valve, as soon as these ones are coming back under water pressure.

The valve body shall be in Ductile Iron GG 25 for a minimum pressure rating of 16 bars and shall have an epoxy coating both internally and externally. The spring shall be of stainless steel 50 CrV4. Disc guide, seat and cover bearing shall be of stainless steel. The pilot control shall be a direct -acting, adjustable spring loaded diaphragm valve, normally open. The pilot valve shall be in bronze or stainless steel and Pilot System tubes in copper. The pilot valve and the by-pass system shall have stopcocks in the inlet and outlet piping to isolate the valve when necessary and a strainer. Pressure gauges for adjustment of the valves shall be attached to the valve body.

The flanges of the PSV shall be in accordance with ISO 2531. The PRV shall be hydrostatically tested at the factory to 40 bars. The range of working pressure shall be as follows:

- upstream side -up to 30 bar
- downstream side -3 bar

The valve shall maintain the upstream pressure within a range of  $\pm 5\%$  with respect to the set pressure.

The Contractor however shall make sure that the size of the valve is correct for the required flow.

Valves shall be installed strictly in accordance with the manufacturer's recommendation. The installation shall include, but not limited to, isolation valves on the upstream and downstream side, by-pass line with isolation valve and pressure gauges including pressure sensors (for connection to a data logger) upstream and downstream of the isolation valve, upstream strainer in main line, pressure relief valve and air release valve on the downstream side all as shown on the standard drawings

### 10.6 PRESSURE RELIEF VALVES

Pressure relief valves of the angle type shall be installed as safety valves downstream of all pressure reducing valves and the size shall be in conformity with the max. PFA 16 bar flow of the upstream PRV. They shall be of the diaphragm actuated type. The valve shall open automatically when the pressure in the line exceeds the set downstream pressure of the PRV. The material shall be similar to those specified for PRV's. The supply shall include the T-piece and the outlet piping complete for installation

### 10.7 FLOW CONTROL VALVE

The Flow Control Valve (FCV) shall maintain a constant upstream planned Flow regardless of the varying inlet/outlet pressure. The valve shall be provided with an integrated low flow by-pass. The FCV shall be of the hydraulically operated type with pilot control. All necessary repairs shall be possible without removing the valve from the line. The Material of the counter –nut is to be Bronze type UE7, the cover is Ductile Iron with epoxy coating of 200 microns, the spindle is stainless steel type 18-8, the skirt is steel type A40, the shutter is steel type Xc38, the flange is Steel type A 40, the O-ring is Nit rile, the screw is steel, the shutter gasket is polyurethane, the tie bar is Stainless steel type 18-8, the bearing is Bronze type U E 7, the lower spring support is to be Cast iron, the spring is to be steel, the upper spring support is to be Steel type XC 38, the nut is bronze type UE7, the setpoint screw is stainless steel type. The main FCV shall be equipped with a special spring, insuring the FCV to stay closed, as soon as the inlet pressure is reading a very low minimum of 2 m, in order to keep the pilot system as much as possible filled with water.

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The FCV shall be equipped with an automatic venting device, permitting to vent automatically the air trapped in the pilot system, as well as in the main valve, as soon as these ones are coming back under water pressure.

The valve body shall be in Ductile Iron GG 25 for a minimum pressure rating of 24 bars and shall have an epoxy coating both internally and externally. The spring shall be of stainless steel 50 CrV4. Disc guide, seat and cover bearing shall be of stainless steel. The pilot control shall be a direct-acting, adjustable spring loaded diaphragm valve, normally open. The pilot valve shall be in bronze or stainless steel and Pilot System tubes in copper. The pilot valve and the by-pass system shall have stopcocks in the inlet and outlet piping to isolate the valve when necessary and a strainer. Pressure gauges for adjustment of the valves shall be attached to the valve body.

The flanges of the FCV shall be in accordance with ISO 2531. The FCV shall be hydrostatically tested at the factory to 25 bars.

The range of working pressure shall be as follows:

- upstream side -up to 16 bar
- downstream side -3 bar

The range of working Flow shall be as defined in the Bill of Quantities.

The valve shall maintain the flow within a range of  $\pm 5\%$  with respect to the set flow.

The Contractor however shall make sure that the size of the valve is correct for the required flow.

The FCV shall be installed strictly in accordance with the manufacturer's recommendation. The installation shall include, but not limited to, isolation valves on the upstream and downstream side, by-pass line with isolation valve and pressure gauges including pressure sensors (for connection to a data logger) upstream and downstream of the isolation valve, upstream strainer in main line, pressure relief valve and air release valve on the downstream side all as shown on the standard drawings.

### 10.8 FLOAT VALVES

Float Valve maintains a relatively constant level in reservoirs by admitting flow into the reservoir in direct proportion to the flow out of the reservoir. It is a hydraulically operated, pilot controlled, diaphragm valve.

The rotary disc type float operated pilot control is installed at the high liquid level in the reservoir and is connected via tubing or pipe to the main valve. As the liquid level changes, the float control proportionally opens or closes the main valve, keeping the liquid level nearly constant.

The valve shall be hydraulically operated, single diaphragm-actuated and globe pattern. The valve shall consist of three major components:

1. the body with seat installed,
2. the cover with bearings installed and
3. the diaphragm assembly.

The diaphragm assembly shall be the only moving part and shall form a sealed chamber in the upper portion of the valve separating operating pressure from line pressure. Packing glands and/or stuffing boxes are not permitted and there shall be no pistons operating the main valve or pilot controls.

No separate chambers shall be allowed between the main valve cover and body. Valve body and cover shall be of Ductile Iron. No fabrication or welding shall be used in the manufacturing process.

- The valve shall contain a resilient, synthetic rubber disc, with a rectangular cross-section contained on three and one-half sides by a disc retainer and forming a tight seal against a single removable seat insert. The disc guide shall be of the contoured type to permit smooth transition of flow and shall hold the disc firmly in place. The disc retainer shall be of a sturdy one-piece design capable of withstanding opening and closing shocks. It must have straight edge sides and a radius at the top edge to prevent excessive diaphragm wear as the diaphragm flexes across this surface.

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- The diaphragm assembly containing a non-magnetic 303 stainless steel stem of sufficient diameter to withstand high hydraulic pressures shall be fully guided at both ends by a bearing in the valve cover and an integral bearing in the valve seat. The seat shall be a solid, one-piece design and shall have a minimum of five-degree taper on the seating surface for a positive, drip-tight shut off.
- No centre guides shall be permitted. The stem shall be drilled and tapped in the cover end to receive and affix such accessories as may be deemed necessary. The diaphragm assembly shall be the only moving part and shall form a sealed chamber in the upper portion of the valve, separating operating pressure from line pressure.
- The flexible, non-wicking diaphragm shall consist of nylon fabric bonded with synthetic rubber compatible with the operating fluid. The center hole for the main valve stem must be sealed by the vulcanized process or a rubber grommet sealing the center stem hole from the operating pressure. The diaphragm shall be cycle tested 100,000 times to insure longevity. The diaphragm shall not be used as the seating surface. The diaphragm shall be fully supported in the valve body and cover by machined surfaces which support no less than one-half of the total surface area of the diaphragm in either the fully opened or fully closed position.
- The main valve seat and the stem bearing in the valve cover shall be removable. The lower bearing of the valve stem shall be contained concentrically within the seat and shall be exposed to the flow on all sides to avoid deposits. To insure proper alignment of the valve stem. The valve body and cover shall be machined with a locating lip. No "pinned" covers to the valve body shall be permitted. Cover bearing, disc retainer, and seat shall be made of the same material. All necessary repairs and/or modifications other than replacement of the main valve body shall be possible without removing the valve from the pipeline.

The manufacturer shall provide a computerized cavitation chart, which shows flow rate, differential pressures, percentage of valve opening, Cv factor, system velocity and of these will be cavitation damage.

The control system shall be sensitive to slight changes in level and consist of a flow clean strainer, a cover mounted variable orifice proportioning pilot control and a remote float, which immediately controls the main valve, maintaining the desired liquid level in the storage tank. This remote control valve shall be according the recommendations and instructions of the float control valve manufacturer.

### 10.9 VALVE INDICATOR PLATES

Valve indicator plates shall be installed for all types of valves installed in mains with diameter DN 100 and larger. This applies also for existing valves which are to be retained in the restructured pipe systems. The Contractor shall liaise with the Employer (Yatta) for respective information about the location of valves and the numbering code to be shown on the plates. The size of the plate shall be 110 mm x 70 mm with 18 exchangeable number or letter fields. The plate shall be scratch and corrosion resistant, made of non-ageing UV-resistant material. The Contractor shall submit samples for approval by the Engineer prior to delivery. The valve indicator plate shall be mounted on a plate of non-corrosive material and shall be fixed against walls or concrete pillars as may be required at a particular location. The Contractor shall allow for the supply of pillars and fixing of approximately 50 % of the indicator plates to it

### 10.10 DISMANTLING JOINTS

Dismantling joints shall be installed where indicated on the drawings for convenient installation or re-installation of valves or similar items.

To prevent any movement of the pipe joints adjacent to closed valves, dismantling pieces shall be in general be of the 'restrained' (short version) according to DIN 2541 or DIN 2547 or flanged adaptors as indicated on drawings or as directed by the Engineer

The body and glands of steel welded dismantling pieces shall be of pressure class PN 16 with nuts and bolts of stainless steel. Surface protection shall be by epoxy resin coating or equivalent. Rubber sealing rings shall be of Perbunan material, nit rile rubber or equivalent.

### **10.11 FLEXIBLE COUPLINGS AND FLANGE ADAPTERS**

Flexible couplings and flange adaptors shall be of ductile iron and of an approved type suitable for making a watertight flexible connection between plain-ended pipes, or between a plain-ended pipe and a flanged fitting (flange adaptor)

Unless otherwise specified, the external and internal surfaces of couplings and adaptors shall be cleaned down to a metallic finish, then primed and painted with epoxy resin paint, applied by an electrostatic process.

All mechanical couplings shall be of appropriate internal diameter and shall be capable of adapting to different pipe materials. They shall be capable of withstanding the maximum working test pressure specified for the pipes to which they connect, including the accommodation of a joint deflection of up to 3° in any direction.

Wedge joint rings shall comply with EN 681 or equivalent, and shall be made of nit rile rubber, ethylene propylene rubber (EPDM) or styrene butadiene rubber (SBR) or other approved materials.

All mechanical couplings and flange adaptors shall be supplied complete with all necessary coupling rings, nuts, bolts, washers and rubber rings. Bolts and nuts of galvanized steel shall be hexagonal with dimensions to DIN 601/555 or BS 4190

In order to ensure compatibility with the associated flanged pipe work the bolt circles on all the flanges of the flange adaptors shall comply with DIN 2501, DIN 28605 or BS 4504 PN 16. Where a Harnessed Steel Flange Adaptor is shown on the drawings, the bolts connecting the flange of the Flexible Flange Adaptor to the Flange of the adjacent fitting shall be replaced by tie-bars threaded at both ends. One threaded end of each tie bar shall pass through holes in the abutting flanges and be anchored by two nuts to make the flanged joints in the normal way. The other threaded end shall be anchored by two further nuts in a corresponding bolt-hole on the flange, soundly welded integrally onto the fitting which it is intended to harness to the adaptor.

The integrally-cast flange on the flange-spigot shall be located such that, after the joint has been made and fully tightened, the flange is about 400 mm axially from the abutting flanges.

The threaded tie bars shall be machined from steel at least equal to that specified for flange bolts of corresponding duty and threaded in the same way. The threaded length shall allow the nuts to be run forward sufficiently to permit complete withdrawal of the tie bars from the flange of the abutting fitting without requiring any other joint to be dismantled.

The strength of the threaded tie-bars in both tension and compression shall be appropriate to the pressure rating of the flanged joints.

### **10.12 SURFACE BOXES AND MANHOLE COVERS**

Ductile Iron surface boxes with round lid which lock automatically, under the own weight with quarter turn, and with built in extension operating process and shall be supplied for operation of gate valves. Surface boxes shall be suitable for a 400 KN load. Shorter surface boxes for casting into concrete slabs may be used with lockable lid and also suitable for a loading of 400 KN.

Hexagonal lids shall be supplied for service (house) connection stop-cocks (ferrules).

Surface boxes shall have a cold applied bituminous black paint coating. The hinge of the lid shall be of non-corrosive material.

Manhole cover will be in Ductile Cast Iron, according to ISO 1083, and will be complying with EN124 Standard, class D400 (40 tons of resistance minimum).

This compliance will be certified by an Authorized and Independent Third Party, and the cover will be so badge with the logo of the Third Party (such as "NF", granted by AFAQ/AFNOR Certification).

It will have to be cast by a manufacture complying to the ISO 9001: 2000 Standard

Frame will have to be moulded with wide anchoring holes, at least 16, to allow effective and durable bedding.

Frame will have at least 18 strong ribs, to provide mastered frame profile capable to withstand traffic stresses

The frame height will be of 100 mm minimum, square shape, with outside dimension of at least 850 mm for a good settlement of the manhole and a right behaviour under traffic stresses.

The clear opening of the frame will be of minimum 600 mm

A sound-proofing gasket in composite material (such as PE+PP) will be installed on the frame to support abrasion and crushing when in function. It will be clamped on the frame, with a specific shape to avoid it moves out from the frame

For an ergonomic opening and lifting once unlocked, the cover will be hinged, with an integrally ductile cast hinge. This hinge will be integral part of the cover, so it resists as well as the cover to corrosion, vandalism and traffic impact

The cover when opened will have to stay in 130 °position to avoid any accidental self closure on workers.

The cover will be round shape, and none ventilated

An elastic spring bar, cast integrally with the cover, will be active that is to say designed to bring a permanent tension between that spring bar, and the cover positioning lugs. It so will provide a remarkable dynamic stability of the cover thanks to 3 points of contact. Furthermore, the spring bar keeps the cover held against the gasket, preventing from rocking.

The elastic spring bar will be such that it will be automatically closed by any load (traffic or pedestrian) when coming over the cover

This spring bar will nevertheless be flexible enough to open by itself when over pressure in the network, and will so avoid any damage in the network (shaft and pipes)

The unlocking of the cover will be allowed by lever effect in the opening box, located on the side of the frame, and will be permitted with usual tools such as pickaxe or bar. It will be potentially opened via a single operation.

An optional locking mechanism to prevent from any intrusion in the network will be foreseen on the cast cover, thanks to a punch able recessed area

An anti-theft device, such as a specific sp line, cast in ductile iron, will be installed in the frame hinge box, to avoid releasing the cover out of the frame.

## **10.13 VALVE CHAMBERS**

### **A. GENERAL**

Valve chambers shall be constructed of reinforced concrete (fair faced) for all valves situated on pipes with a diameter  $\geq 150$  mm (gate valves, air valves, washouts, pressure reducing valves, flow meters...), according to the Standard Details Drawings.

Valve chambers and similar structures shall be built into the pipe lines as demanded and in accordance with the Typical Drawings. Given dimensions on the drawings are to be verified by the Contractor so as to suit the pipe installation and the prevailing conditions on site.

Concrete supports for pipes, valves and any other fittings shall be placed at appropriate locations inside the chamber under the direction of the Engineer (even if not shown on the Typical Drawings).

Ductile iron manhole covers with frames shall be installed for all valve chambers as specified or shown on the drawings. The wording on each cover shall be agreed with and approved by the Engineer prior to ordering.

Covers to be used in surfaces which are subject to vehicular traffic shall be tested for a load of 40Tons.

Manhole covers with bearing capacities of 40 Tons according to DIN 1229 shall be installed as instructed by the Engineer.

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Diameters of cover manholes shall be as follows, if not otherwise indicated:

600mm clear opening unless otherwise specified.

Two pairs of keys for use with each type of cover shall be handed over by the Contractor after completion of the Contract at no extra cost.

All valve chambers shall be equipped with step irons, as indicated in the Drawings or as directed by the Engineer.

Step irons shall be of malleable ductile iron, according to DIN 1211 galvanized iron or as directed by the Engineer.

All valve chambers shall have pump sumps installed as shown on the Typical Drawings or instructed by the Engineer.

Types of draining for the valve chambers shall be according to the Typical Drawings or decided on site.

Penetration holes with GS sleeve pipes shall be inserted into the ceiling of valve chamber (details of which are shown on the Typical Drawings); so as to incorporate the extension spindles of the valves inside the chambers.

Ventilation pipes of DN 100 or DN 150 shall be installed at the highest possible point in all valve chambers (considering traffic load) and led to the nearest convenient outlet above ground. End of pipe to be flanged with a stand pipe DN 100/150 of ductile iron equipped with protection cap including non-corrosive insect screen.

If agreed by the Engineer, the ends of ventilation pipes may be constructed as a double flanged bend as shown on the drawing.

Exposed parts of vent pipe are to be painted with a weather-proof material as instructed by the Engineer.

Structural calculations including reinforcement drawings for all valve chambers shall be made by the Contractor. These calculations are to take into consideration the prevailing load and soil conditions.

Reinforcement of concrete chambers shall be included in the unit rates of valve chambers.

Minimum requirement of steel reinforcement:

2 layers of 12 mm dia. at 200 mm spacing crosswise, the Contractor shall submit structural calculations for the chambers for the Engineer's approval

All external pipe work before entering and after exiting a reinforced concrete chamber shall be fitted with flexible joints at a minimum distance of 300 mm from the external face of the chamber.

The RSS testing laboratory will submit certified copies of test results, in duplicate, directly to the Engineer's Representative and Contractor, promptly upon completion of any tests.

### **B. STEEL PIPES**

Steel pipes shall comply with the requirements of BS 534 "Specification for steel pipes, joints and specials for water and sewage".

In addition, the following shall apply:

- 1) Pipes shall be Grade 430 and manufactured by a seamless process to ISO 2604 Part 2 – TS9 Cat. II or submerged arc welded process to ISO 2604 Part 6 – TSAW 9 Cat VI.
- 2) Pipe outside diameters and pipe wall thickness shall comply with Table 1 of BS 534.
- 3) Pipes shall be supplied in lengths within the range 6m – 6.5m.
- 4) 20% of each size diameter of pipe shall be supplied true diameter throughout for cutting, etc. These pipes shall be clearly painted with an identification mark over the whole length of pipe.
- 5) .All new welds made during the fabrication of the fitting shall be subject to non-destructive testing using either radiological, ultrasonic or dye penetrants dependent upon the geometry of the weld.
- 6) Flanges will be to BS4504. Flexible joints shall be by the use of flexible couplings to AWWA C219 and of approved pattern, or for nominal diameters not exceeding 500 mm may be socket and spigot joints with rubber gaskets subject to the specification herein provided.
- 7) Fitting ends for use with flexible couplings shall be true ended with the ends appropriately prepared for the type of coupling provided.

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- 8) Joints for site welding shall comprise a socket and special spigot (bell joint with air chamber) to SSRN 243 such that the internal coating of the spigot shall be undamaged during the welding.
- 9) Pipe ends shall be protected from corrosion with bitumen, maximum 3m thick, suitable for potable water and comply with the requirements of BS 6920 Part 1.
- 10) Internal corrosion protection shall be of bitumen, concrete or cement mortar all conforming to the requirements of BS 534. pipe lining material shall be suitable for potable water and comply with the requirements of BS 6920 Part 1.
- 11) External corrosion protection shall be reinforced bitumen sheathing.

### C. CONCRETE WORKS

#### 1. General

The Contractor shall provide all labour, materials and equipment necessary for the various classes of concrete and the reinforcing steel as shown on the Drawings and as specified, according to DIN 1045 or an equivalent standard.

In general, B300 concrete is required for cast in-situ structures and other construction works with substantial reinforcing steel and/or complex form work. (E.g. valve chambers etc.).

B250 concrete is required for simple support structures and construction with little steel reinforcement and / or little form work. (e.g. conc. thrust blocks, pipe encasement, road crossing, etc.).

B200 concrete has a different composition and lower strength than B300 and B250. It is generally used as blinding or levelling concrete.

#### 2. Concrete materials

Concrete shall comprise Portland cement, fine aggregate, coarse aggregate and water proportioned and mixed as described in this Specification.

Course aggregate shall consist of crushed stone or gravel composed of durable pieces, free from organic matter, chemically stable, free from undesirable adherent coating such as oil, clay, petroleum products etc. and not containing deleterious substances. Course aggregates shall comply with DIN 1045, or BS 822

Fine aggregate shall consist of natural silica sea sand, subject to approval, other inert materials with similar characteristics having durable particles, or a combination of both DIN, BS requirements shall be valid:

Sea Sand; The natural silica sand can be used, in concrete mix provided that the percentage of Sea sand by weight does not exceed 23 percent of combined aggregate used for one cubic meter of concrete or as determined by concrete mix design (ACI).

Other Inert Materials: Crushed stone, fine aggregates or other combinations of inert materials having durable particles can be used for concrete mix.

The fine aggregate shall not contain deleterious substances and shall comply with DIN 1045, BS 882.

Portland cement shall comply in all respects with DIN 1164 or AASHTO standard specification M85 Type I, BS 12, for Ordinary Portland Cement, for Portland cement unless otherwise indicated.

Each consignment of cement shall be accompanied by a certificate from the manufacturer giving results of their tests. If this certificate is not made available, then samples may be taken from different bags or containers of the consignments suitably packed and sent for testing to any approved Materials Testing Laboratory the Palestinian Territories or to the Engineer's laboratory on site, at the Contractor's expense.

All water used in concrete shall be clear, fresh water free from oil, acids, alkali, sugar, vegetable substances or any other contaminating agent.

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If required by the Engineer's Representative, the water shall be tested in accordance with BS 3148, ASTM D-512, 516, AASHTO T-26 or in comparison with distilled water.

Comparison shall be made by means of standard cement test for soundness, time of setting and mortar strength. Any indication of unsoundness, change in time of setting of plus or minus 30 minutes or more or a decrease of more than 10 % in strength from results obtained with mixtures containing distilled water shall be sufficient cause for rejection of the water being tested.

### 3. Mixing concrete

All concrete shall homogeneous and thoroughly mixed in mechanically operated mixers. There shall be no lumps or evidence of un-dispersed cement. Uniformity of concrete mixtures will be determined by differences in slump or by variations in the proportion of course aggregate.

The difference in slump, determined by comparing slump tests on two samples of mixed concrete from the same batch or truck load, shall not exceed 20 mm. Variation in the proportion of course aggregate will be determined from the results of tests of two samples of mixed concrete from the same batch or truck load and the difference between the two results shall not exceed 3%.

ACI requirements for concrete handling, mixing etc. shall apply. The Contractor, at his own expense, shall furnish samples of the freshly mixed concrete and provide satisfactory facilities for obtaining the samples.

### 4. Placing concrete

The Contractor shall obtain the approval of the Engineer to his proposed arrangements before commencing concreting.

All placing and compacting of concrete shall be carried out under the direct supervision of a competent member of the Contractor's staff. The Contractor shall regard the compacting of the concrete as work of fundamental significance, the object of which shall be to produce a concrete of maximum strength and water tightness.

Concrete shall be thoroughly compacted during placing and shall be thoroughly worked around the reinforcement and any embedded fixtures and into corners of the formwork and moulds. Mechanical vibrators shall be used for compacting.

Unless otherwise agreed by the Engineer on the basis of satisfactory site trials concrete shall not be dropped into place from a height exceeding two meters. Chutes or funnel tubes shall be used where heights exceed two meters.

If the ambient temperature reaches 40° C, concreting operations shall be discontinued unless the Contractor has adequate means of cooling the ingredients and keeping the temperature of mixed concrete below 32°C.

In any event, the surface of freshly placed concrete shall be protected against drying by covering it with wet Hessian cloth or burlaps and, where practical, continuous water curing shall be applied during the first few hours after placement. All concrete shall be kept moist on exposed surfaces for a period of 2 weeks according to DIN 1045.

When the ambient temperature is less than 2°C, all concreting operations shall stop and the freshly laid concrete shall be protected against freezing, unless the Contractor uses adequate means to keep the temperature of mixed concrete above 13°C for thin sections and 7°C for massive sections.

### 5. Steel Reinforcement

Steel reinforcing bars shall be deformed, high tensile billet steel bars for concrete reinforcement conforming to the specification ASTM A615 Grade 40.

Bars should have the following characteristics: High Median Minimum yield strength 4200 kg/cm<sup>2</sup> 2760 kg/cm<sup>2</sup>

Mesh reinforcement shall conform to the specifications of ASTM A185. The gauge of the wire and the dimensions of the mesh shall be as shown on the Drawings or specified herein.

Each bundle of steel shall be tagged at the mill with an identifying mill tag, showing the name of the mill and the melt or batch number. This tag shall be a metal tag attached with a lead seal and placed in an exposed position

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for easy identification by the Engineer's Representative. Certified mill tests on each batch showing physical and chemical analyses shall be available to the Engineer's Representative at the time of sampling. Two or more samples, each 750 mm long, shall be taken at random from each size in each melt or batch. All test samples shall be provided by the Contractor at his own expense. For having the acceptance /or rejection of shipments of steel.

Reinforcement steel shall conform accurately to the dimensions shown on the Drawings and approved shop drawings. Bars shall not be bent or straightened in a manner that will injure the material. Bars with kinks or improper bends shall not be used. Heating with torches shall not be allowed.

Before concrete is placed, the reinforcement to be embedded shall be free of mortar, oil, dirt, loose mill scale and loose rust, and other coatings of any character that would destroy or reduce the bond.

Reinforcing bars shall be placed as shown on the Drawings and shall be firmly and securely held in position at intersections with wire and by using pre cast mortar blocks or galvanized metal or plastic chairs, spacers, metal hangers, supporting wires, and other approved devices of sufficient strength to resist crushing under full load

### 6. Formwork

Formwork shall be constructed to attain the required surface textures of the structures and be such that it remains rigid and grout-tight during the placing and setting of the concrete. Formwork shall be fixed in perfect alignment and to the true shape and dimensions of the permanent work shown on the Drawings.

Before each concreting operation is commenced formwork shall be carefully examined and cleaned out and the concrete contact faces of the works shall be treated with an approved release agent. The Contractor shall take particular care to ensure that no release agent comes in contact with reinforcement.

Forms for chambers and all exposed surfaces shall be constructed of plywood or metal or glass reinforced plastics, at the option of the Contractor. Unless otherwise directed by the Engineer's Representative, all exposed sharp edges of finished concrete shall be chamfered with triangular fillets (arises) not less than 20 mm by 20 mm, to prevent mortar runs and to preserve smooth, straight lines. All inserts, step irons, anchors, etc., shall be solidly and properly fixed to the formwork at locations shown on the Drawings.

Concreting shall not begin until the Engineer's Representative has inspected the formwork, reinforcement etc, and approved the pour.

### 7. Testing

The Contractor shall make all necessary arrangements for the sampling and testing of fresh and hardened concrete in accordance with the provisions of DIN 1048 or BS 188 and shall supply all necessary apparatus, labour, materials and transport.

Slump tests shall be carried out according to ASTM C 143 at such times and places as the Engineer's Representative may direct and shall be used as a guide to the consistency of each class of mix. During the course of construction of the works concrete test cubes in sets of six shall be made at such times and places as the Engineer's Representative may direct and in any case at no less than the average rate of one set of cubes for every 18 cubic meters of concrete placed. In judging compliance with the characteristic strength requirements of this Specification, three cubes from each set shall be tested at seven days and the remaining three cubes shall be tested at twenty eight days. At any time more than 28 days after the placing of the concrete the Engineer may request that core samples be taken for testing at an approved laboratory. Such instruction would only normally be given when cube results indicate a possible problem of concrete quality and core samples shall therefore be taken and tested at the Contractor's expense.

Tensile strength tests and bending tests from the samples taken as described under par. 4.6 shall be carried out as directed by the Engineer according to ASTM A 615 M.

Compression strength tests of concrete cylinders or concrete cubes as well as tensile strength tests and bending tests of reinforcement shall be carried out as described above. The Contractor shall be responsible for handling, storing, and transporting of all test materials to an approved laboratory.

## **11 ELECTRICAL WORKS**

Refer to General Technical Specifications for the Construction of Concrete Water Tanks.

## **12 GENERAL MECHANICAL SPECIFICATION**

This Specification is intended to indicate the minimum standard of design, workmanship and materials acceptable in this project. The itemized specific requirements are given in the Particular Specifications.

### **12.1 GENERAL REQUIREMENTS AND WORKMANSHIP**

All supplied parts shall be designed and constructed for the maximum stresses occurring during fabrication, erection and continuous operation. All materials shall be new and both workmanship and materials suitable for the service the units are to be subjected and shall conform to all sections of the Specifications.

The general mechanical and electrical design of the Works and particularly that of the bearings, contacts, and other such wearing parts shall be governed by the need for a long period of service without frequent maintenance and attention.

Unless otherwise specified, all items of the Works shall be rated for continuous service at the specified duties under the prevailing atmospheric and operational conditions of the Site.

All parts subject to wear shall be readily accessible. Provision shall be made for taking up wear in all bearings and other wearing parts or for easy replacement if adjustment is not practicable.

Wherever practical the Contractor shall ensure the maximum interchangeability of similar items from alternative suppliers.

Suitable packers, shims, adjustment and the like shall be fitted for ease of adjustment and realignment of all machinery units with particular attention given to combined sets.

The design of piping systems shall achieve proper support to prevent damage from vibration during operation and during maintenance using generally accepted practices. The design shall also provide proper flexibility and normal accessibility for operation, maintenance, and thorough cleaning. Installation shall be in a neat and orderly arrangement adapted to the contour of the machine and not obstructing access openings.

All pipes shall be checked for alignment and mating of connections before being secured and pipes shall be in straight line and grade.

Pumps shall be designed to meet the operational duties under the Site conditions as specified. Pumps shall be designed to keep constant performance. Waterways through the pump and impeller shall be smooth and free from recess and projections.

### **12.2 PIPE WORK**

#### **A. PIPING**

##### **1. General**

This specification gives general guidelines to be applied in piping and support design, manufacturing and installation.

Each part of the piping system shall be complete in all details and provided with all valves and accessories necessary for satisfactory operation.

All piping shall be grouped wherever practical and shall be erected to present a neat appearance. Pipes shall be parallel to each other and parallel or at right angles to structural members and shall give maximum possible headroom.

Pipes erected in pumping stations and valve chambers shall be arranged to provide maximum access.

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Sufficient space is to be allowed for accessibility for servicing. No mechanical joints shall be embedded.

Adequate allowance shall be made for expansion and contraction in pipes by the inclusion of flexible, proprietary joints in the piping system.

All reductions in sizes shall be by the use of proprietary fittings or fabricated sections.

Pipe connections to equipment and valves shall be arranged for easy dismantling and removal.

All pipe work shall be free of corrosion and without any signs of scaling, pitting or excessive weathering to the satisfaction of the Engineer. Pipes stored on Site shall be kept clean and off the ground and stored under cover. Pipes corroded or distorted beyond standard tolerances shall not be used.

The Contractor shall ensure that all pipes are free from internal obstructions. All burred and cut ends of pipes shall be well reamed and filed to ensure that the full bore of the pipe is maintained. The Contractor shall take special care to prevent dirt or rubbish entering the open ends of all pipework during storage and erection. Screwed iron caps or plugs or plastic caps shall be used for this purpose. Wood, rag, paper or other inadequate material shall not be considered as adequate protection. Should any stoppage in the circulation occur after the various systems have been put into operation which proves to be due to non-compliance with these requirements, the Contractor shall rectify the matter at his own expense.

The Contractor shall ensure that at no part of any installation dissimilar metals are include, which will promote chemical or electro-chemical action, causing a weakening or failure of the service. This applies not only to the internal surfaces but also the external surfaces of all pipes, fittings, valves, plant, vessels, pumps and any other item of equipment in the installation.

Any pipe work which does not conform as to material and workmanship with this specification shall be removed and replaced at the expense of the Contractor.

Adequate supporting and anchoring arrangements for all pipes shall be designed and installed by the Contractor.

All pipes connected to pressure vessels, pumps, compressors and the like shall have flanged connections.

The Contractor shall ensure that the design and layout of his pipe work shall be such that no torque or other loads from the starting of the equipment shall be transmitted into the pipe work and shall provide additional joints or supports as may be necessary.

The joints and connections in pipes shall be made either with flanges or by welding. Flexible couplings shall be used only in flexible joints and dismantling joints. The pipes shall be supported on both sides of a flexible joint.

Drilling of flanges shall comply with EN 1092, or equivalent. The gaskets shall be of reinforced nitrile rubber, thickness 3 mm.

Threaded joints shall be avoided and the use shall be limited to sizes smaller than DN 65. For dismantling conical connectors shall be used.

All nuts, bolts, washers, flanges, gaskets, flanges tied adapters, drain valves, special connection pieces, supporting hangers, brackets or clips and temporary supports for the pipework, together with all terminal point connection materials shall be supplied and installed under this contract.

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PARTICULAR TECHNICAL SPECIFICATIONS**

**2. Nominal Dimensions**

DIN standards ISO recommendation (DIN 2458 and DIN 17100, or equivalent) shall apply.  
Nominal Size (DN) and Outsize Diameter (Do) of Carbon Steel DIN and ISO, Fe 37B and stainless steel.

**Table 12.1: Nominal dimension of Carbon Steel and Stainless Steel**

DN	6	10	15	20	25	32	40	50	(65)
Do	10.2	17.2	21.3	26.9	33.7	42.4	48.3	60.3	(76.1)
DN	80	100	(125)	150	200	250	300	350	
Do	88.9	114.3	(139.7)	168.3	219.1	273.0	323.0	355.6	
DN	400	(450)	500	600	700	800	1000	1200	1600
Do	406.4	(457)	508	610	711	813	1016	1220	1620

Pipe sizes shown in brackets should be avoided if possible.

**3. Stainless Steel Pipe works**

The material of the pipe and pipe specials shall be EN 1711 or equivalent.

The stainless steel pipes shall be fabricated by longitudinally welding according to EN 2234 or equivalent.

The Tee- pieces shall be factory made. The flange joints shall be with weldable collars of stainless steel and loose flanges of hot dip galvanised carbon steel. The gaskets shall be of

The minimum wall thicknesses of the stainless steel pipe barrel and the pipe fittings shall be as shown in Table 12.2 below.

**Table 12.2: Wall Thickness of Pipe Barrel**

Nominal size	Wall Thickness of Pipe Barrel mm *
Up to and including DN 80	1.6
DN 100 up to and including DN 250	2.0
DN 300 and 350	2.6
DN 400	3.2
DN 500 and 600	4.0
DN 700	5.0
DN 800	6.3

The wall thicknesses of non-standard Tee-pieces and cross pieces shall be calculated by the Contractor and submitted to the Engineer for approval. Full internal vacuum shall be taken into account in the dimensioning calculations of the fittings.

A 2 mm thick weld-on puddle flange shall be provided in all embedded wall transition pieces. The diameter of the puddle flange shall be not less than 150 mm + the pipe outside diameter. All puddle flanged pipe specials shall be prefabricated by the Supplier. The stainless steel wall transition pipes shall not be connected to the reinforcement.

#### 4. Supports and Fixings

Recommended maximum free spacing between supports for stainless steel pipes shall be as in Table 12.3 below.

**Table 12.3: Maximum free spacing between supports for stainless steel pipes**

DN	10	15	20	25	32	40	50	65	80
Span (m)	2.0	2.2	2.4	2.7	2.9	3.1	4.0	4.3	4.7
DN	100	125	150	200	250	300	350	400	500
Span (m)	5.2	5.5	5.9	6.4	6.8	7.5	7.8	8.1	9.0
DN	600	700	800						
Span (m)	9.5	10.3	10.7						

The table is valid only for straight pipe runs. Pipe headers furnished with valves or other heavy components must be adequately supported at each heavy component such that no excessive stresses or deflections are developed to the piping or connected equipment.

Unless otherwise specified all supports, anchor bolts, screws, straps, clips, brackets, steelwork, etc. and other fixings shall be provided by the Contractor. Where applicable the manufacturer's instructions shall be followed. They shall be of ample section to withstand the forces created by operation of the equipment.

All piping shall be supported away from the building structure.

Hanger inserts to be set in place before concrete is poured.

Anchor bolts less than M 12 size shall not be used for fastening of mechanical equipment (pumps, compressors, gears, pipes etc.).

All submerged supports, anchor bolts and fasteners shall be of stainless steel. Washers and nuts of the same material shall be used in bolted joints. Other supports, anchor bolts and fasteners shall be of hot dip galvanised steel. Washers shall be provided under all nut and bolt heads, material shall be same as for the bolts. The overdrive of the bolt in an assembled joint shall not be less than one mm over the nut nor more than one height of the nut.

The anchor and foundation bolts shall be completed with hexagonal nuts and washers.

#### 5. Welding

The welding of the pipes and other appliances shall be performed according IIW (International Institute of Welding) recommendations and regulations.

The seams shall be visually inspected on the Site for the smoothness, height of the seam, ridge and root faults and cracks and the uniformity of the seam with the basic material shall be detected.

The Engineer may, in order to guarantee the quality and safety of the work require the Contractor to take random x-ray exposures of the seams (about 10 % of all seams), at the expense of the Contractor. The quality codes utilised shall be according to IIW classification. The exposures shall be taken from the seams chosen during the visual inspection. The inspection concerns both factory's made and Site welded seams. The manufacturer of the pipes is not required to submit x-ray certificate of his products. During the site inspection the following procedures will apply:

- If faulty seams are found, the Contractor shall be obliged to cut out the joint and the seams properly on his own expense.
- X-ray exposures of the re-welded seams shall be taken at the expense of the Contractor. Additionally each faulty seam found will lead to the taking of one penalty exposure of the same welders work as the faulty one. The cost of this shall also be at the Contractor's own expense.

All the welders on Site shall be experienced and adequately trained on the working methods (e.g. for carbon or stainless steel, for pipe or sheet welding on the valid material and for arc, MIG or TIG welding separately) and their qualifications shall be submitted to the Engineer for review.

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The Contractor shall submit to the Engineer for approval in advance the welding methods he intends to use.

Welding rods shall be stored and used dry. If necessary they shall be dried with heat of 150 to 250 °C if found to be moist or wet and unsuitable for use. Rods shall be suitable for the base material. The thickness of the seam shall not exceed the thickness of the base. The slag and scale shall be removed with the tools suitable for the material (e.g. stainless steel tools are required for stainless steel welding). The mechanical cleaning of the seams shall be done with steel brush after chipping off the slag.

The welding arc shall be lit so that no cracks are left visible outside the weld. When scratches occur they shall be ground of to the clean material and afterwards covered by welding if the grinding has gone too deep. With stainless steel welding the following shall apply:

- Handling of the stainless steel material shall be with mild steel tools.
- Grinding shall be performed with discs and abrasive cloths impregnated with artificial resin or rubber. Traces of the grinding shall be pickled.
- After the mechanical cleaning the seams in the stainless steel structures shall be pickled with suitable pastes.

## B. VALVES

### 1. General

All valves shall be designed to the minimum working pressure as shown on drawings and/or detailed in Particular Specification. Flanges for valves shall comply with EN 1092-2 for cast iron flanges, or equivalent.

Unless otherwise specified, all valves shall be anti - clockwise opening and operated by hand wheel for up to 300 mm, above 300 mm geared actuators shall be used. The maximum effort required to be applied at the circumference of the hand wheel to operate the valves against the maximum unbalanced head shall not exceed 200 Nm.

Unless detailed otherwise all hand wheels shall have the words "open" and "close" in English with arrows indicating the direction of rotation cast on. All hand wheels shall be of a solid cast type.

Valves of all types shall be capable of withstanding corrosion in the ambient conditions and any parts manufactured from a material which is not itself corrosion-resistant must be protected.

Works tests will not be witnessed except where so specified or required by the Engineer. A certificate from manufacturer for shop testing shall be provided for the approval of the Engineer.

### 2. Gate valves

Gate Valves shall be resilient seated with smooth straight through bore. Body and bonnet shall be of cast iron with non-rising stem of stainless steel spindle. The wedge shall be of ductile iron, inside and outside fully rubberized with vulcanized elastomer, the wedge guide of wear resistant plastic with high gliding features. The axis and the bolts are stainless steel. The seal is made of elastomer.

### 3. Butterfly Valves

The butterfly valves shall be manufactured according to the ISO 5752, or equivalent. The seepage free shut-off pressure difference of the valve shall be 10 bars against atmospheric pressure.

The body shall be made of cast iron and rubber lined. The disc shall be of cast iron and the shaft of stainless steel. Removal and replacement of seals without removing the valve shaft shall be possible.

### 4. Non return valves for water supply

Non return Valves shall be of double flap type, with low head losses. The material of the different parts shall be as follows:

- Body: cast iron;
- Flap: copper alloy;
- Shaft: stainless steel 304 according to EN 10088;

- Circumferential seal: rubber NBR or EPDM;
- Spring: stainless steel 302 according to EN 10088.

#### **5. Dismantling joints**

Dismantling joint shall be of free or self abutted type depending on the application. The material of the different parts shall be as follows:

- Fixe body: S235JRG2 steel according to EN 10025;
- Sliding body: S235JRG2 steel according to EN 10025;
- Compression flange: S235JRG2 steel according to EN 10025;
- Circumferential seal: rubber EPDM;
- Diameter and operating pressure: the same as the devices they are associated to;
- Nominal pressure: the same as the devices they are associated to;
- Compression flange: the diameter and nominal pressure will be identical to those of the main flanges;
- Rods protection against corrosion: zinc chromate or equivalent.

#### **6. Actuators**

Actuators shall be suitable for the medium, temperature and pressure of the system into which they are being fitted.

Settings and emergency operation shall be possible with the use of handwheel. By operating the hand/auto lever the motor drive is connected and the manual drive shall automatically be disconnected. During electric operation the hand wheel shall not rotate.

Actuators shall be adjusted linked to the regarding valve at the manufacturer's works to ensure that they provide the correct fully open position and fully closed position. Mechanical adjustable stops shall be provided to prevent over travel of the valve in the open and closed positions. The operating torque at the hand wheel level shall be less than 150 Nm.

Electrically operated valves shall incorporate an actuator providing sufficient force to fully open and fully close the valve against the maximum system differential pressure.

The gearing of the actuators shall be either of the positive lock worm gearing type, or of the travelling nut type. The electrical actuator must be equipped with electromechanical brake and overtorque protection at opening/closing with dry contacts.

The enclosure of the actuator shall be minimum IP 55 including the cable glands.

The actuator shall be provided with:

- A motor three phases 400 V 50 Hz IP65 class F insulation, temperature rise 70 K;
- Type of duty: short-time S2 - 15 min;
- Terminals for connecting all external wiring;
- Motor protection by three thermo-switches placed in the windings;
- Built-in motor protection with anti-condensation heater;
- A potential free contact indication open-close position;
- Adjustable limit switches for electric control;
- Mechanical blinker transmitter for running indication.

#### **7. Flexible Couplings**

Axially restraining flexible couplings shall be provided at least where shown on the Drawings. Each joint shall be complete with all associated fittings and shall be installed in accordance with the manufacturer's instructions.

Max. allowable pipe movement in couplings shall be about 10 mm and shall be achieved by deformation of the sealing ring, not by sliding action of the ring on the pipe.

### **C. TESTING**

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During and after installation the Contractor shall take all reasonable measures, including the provision of plugs where appropriate, to prevent ingress of debris into pipe work systems. Before testing of a pipe work system commences the Contractor shall ensure that it is clean and contains no obstructions.

All pipe work systems shall be tested by the Contractor for water tightness and stability.

The Contractor shall provide all necessary plant and equipment, including pressure gauges, struts and thrust blocks, as may be necessary for effectively testing the pipelines to the specified pressures, and shall be responsible for the supply and disposal of all water as set out in the Contract.

Should any inspection be unsatisfactory or any test fail, the Contractor shall at his own expense re-execute defective work following which cleaning and testing will be repeated.

Before applying the test pressure, all air shall be expelled from the pipe. After all the air has been expelled, all cocks shall be closed and the test pressure applied as specified above. The line shall be filled slowly to prevent possible water hammer.

The specific method of testing, i.e. from pump pedestal, discharge pipe or valve chamber over-pumping connection, shall be agreed with the Engineer prior to the commencement of the test.

### 12.3 HOISTING EQUIPMENT

The hoists and cranes shall be electrically operated (unless otherwise specified in the particular specifications) for travelling, traversing and hoisting by endless steel chains. The supply voltage is 3 phases 400 V - 50 Hz.

All chains shall be of electrically welded steel, heat treated, polished and accurate to pitch.

Chain hoist shall consist of frame, casing, reduction gear and flanged load sleeve with precision roller bearings, load and operation chain, overload limiter, mechanical brake and safety hook lock.

Overhead bridge travelling cranes shall consist of electrically operated hoist, travelling and traversing rails, stoppers, and all necessary components such as fixing bolts and the like for proper and efficient operation of the crane. 2 sets of wire slings with appropriate capacity and length will be provided.

All members of a crane shall have a minimum safety factor of 5 based on ultimate strength of materials. Maximum deflection of the bridge shall be 1/800 of the span with given rated load. The Contractor shall ensure all civil works line and level tolerances are within the limits set by the crane manufacturer.

The command shall be carried out according to the following specifications:

- 2 lifting speeds of the electric winch;
- 2 speeds of the transversal movements;
- 2 speeds of the longitudinal movements;
- Movements electrically controlled by a control pendant isolated box. All orders will be identified with an indication of the direction of movement corresponding to each of them;
- Brake to hold automatically, instantly and securely suspended load during a power outage,

All hoisting equipment shall comply with the local regulation. A certificate and license shall be provided by the Contractor to demonstrate compliance with these requirements.

### 12.4 WATER HAMMER PROTECTION SYSTEM

Not applicable.

### 12.5 VENTILATION

The air intake grids meet the following specifications:

- Stainless steel construction;
- The total area of grids will be determined so that the speed of passage in the latter does not exceed 3 m/s;
- Fixed blades protection against the ingress of rainwater;

# COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM

## PARTICULAR TECHNICAL SPECIFICATIONS

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- Anti-volatile stainless steel mesh 10 x 10 mm arranged at the rear of the fins.

The fans meet the following specifications:

- Pressure applied to be defined according to head losses within the ventilation system stainless steel construction;
- Maximum top speed 1,500 rev / min;
- Three phases supply 400 V - 50 Hz;
- Protection grids;
- Noise levels below 65 dB (A) at 5 meters.

## 12.6 SURFACE PROTECTION

### A. GENERAL

The surface preparation requirements shall be based on EN ISO 12944, or equivalent and also on the paint manufacturer's requirements and the Engineer's instructions.

Equipment not to be painted are stainless steel tanks, vessels, piping, etc. and piping to be insulated.

All items that require surface protection shall be delivered to Site with at least workshop, factory, manufacture's etc. applied undercoat and topcoats leaving only the final colour painting to be applied at Site.

The paint materials selected for the paint systems can only be changed on the written order by the Employer.

All gauges, surfaces of bearings, open pipes, pumps, electric motors, etc. that are not to receive surface protection shall be protected during painting operations.

The steel structures which will be embedded in concrete shall be painted for 50 mm of the length inserted into the concrete during pouring.

Every coat in a paint system shall be a different colour to facilitate measuring the coat thickness. Safety colours shall be according to the local regulations.

Finish or top colours for all items except items Site manufactured ones shall be in manufacturer's standard colours and the items delivered to Site in these colours. Finish or top colours of Site fabricated items will be as advised.

Un-insulated steel and cast iron pipes shall be coated with anti-corrosive paint, colour complying with flowing substance.

### B. PAINT MATERIALS AND STORING

Paint materials are delivered to the Site in manufacturer's packages.

The paint materials shall be stored in a well-ventilated room all according to the paint manufacturer's requirements.

### C. STEEL SURFACES

Pre-cleaning shall be carried out before rust removal and painting. After pre-cleaning the steel surfaces should be blasted EN ISO 12944, or equivalent.

### D. PAINTING

EN ISO 12944 or other equivalent national or international standards shall apply.

Airless painting methods shall be used. Painting will only be permitted in weather conditions that meet the paint manufacturer's requirements.

## COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM PARTICULAR TECHNICAL SPECIFICATIONS

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Shop primers and washes shall be used according to the paint manufacturer's requirements.

### E. TRANSPORTATION AND HANDLING OF PAINTED STRUCTURES

All painted surfaces must be allowed to dry long enough before the structures are transported. Textile slings, rubber or plastic covered wire ropes or hoisting straps should be used for lifting. If bare wire ropes or chains are used, a protective padding shall be inserted between the painted surface and the lifting device.

During storing of the painted structures a protective padding should be used between the painted surfaces.

Damaged areas shall be repaired to reinstate the original paint system.

## **13 INSTRUMENTATION**

### **13.1 GENERAL**

All measurement instruments belonging to same sub-category shall be from one manufacturer.

All instruments shall be of range and size specified in the Particular Specification or shown on the Drawings and suitable for the chemical properties to be measured (e.g. chlorine.).

Instruments having remote display or a calculation function shall also record same values and be readable at the instrument locally.

Accuracy  $\pm 1\%$  of full scale if no special requirement, with transmission distance of minimum 1 km.

Input voltage shall be 220 V AC if not specified different. All instruments should compatible with the SCADA spec.

### **13.2 ELECTRICAL MEASUREMENT CIRCUITS**

Systems shall be provided as required with voltage stabilizers to ensure that proper voltages exist between each phase and neutral and between phases.

Maximum error in any measurement signal is 2 % from the real value. Standard 4 to 20 mA current output/input signal shall be used for measurements.

### **13.3 ELECTROMAGNETIC FLOW METERS**

- A. The electromagnetic flow meter shall be according to ISO 4064, OIML R49 or equivalent.
- B. Magnetic flow meter systems shall be the low frequency electromagnetic induction type which produces a DC pulsed signal directly proportional to and linear with the liquid flow rate. Complete zero stability shall be an inherent characteristic of the flow meter system. Each magnetic flow metering system shall include furnishing a metering tube, signal cable, transmitter, flow meter grounding rings, transmitter enclosures, antennas, external batteries and all related items.
  1. The metering tube shall have:
    - a. Pressure ratings as indicated and in accordance with the requirements of piping specifications.
    - b. EPDM or Butyl Rubber Liner, conforming to the manufacturer's recommendation for the intended service.
    - c. Electrodes shall be Hastelloyor Higher grade
    - d. Metering tube housing rated for IP68, suitable for continuous submergence in up to 3 meters of water, if installed in a below grade vault or any other area with reasonable potential for submergence.
    - e. Epoxy protective coating.
    - f. Grounding rings shall be 316 stainless steel. Grounding rings shall be designed to protect and shield the liner's edge interface from abrasion at the meter end.
  2. The microprocessor-based signal converter/ transmitter shall have:
    - a. DC pulse technique to drive flux-producing coils.
    - b. Six-digit LCD displays for flow rate, percent of span, and tantalization.
    - c. An operator interface with keypad which responds to English text entry.
    - d. Automatic range change.
    - e. Capable of measuring flow in both directions.
    - f. 3 totalizer: Configurable to Forward, Reverse and Bidirectional net flow.

## COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM PARTICULAR TECHNICAL SPECIFICATIONS

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- g. Programmable parameters including meter size, full scale Q, magnetic field frequency, primary constant, time constant.
- h. Data retention for a minimum of 5 years without auxiliary power from main source or battery.
- i. Self-diagnostics and automatic data checking.
- j. Ambient temperature operating limits of -20 to 60 degrees C.
- k. Remote transmitter enclosure rated for IP68.
- l. Data transmitter and flow meter shall be provided from the same manufacture.
- m. Transmitter for flow meter with 2 input 1st for flow sensor & 2nd for pressure sensor.

### C. Calibration

Calibration: Each flow metering system shall be hydraulically calibrated at a facility that is traceable to the ISO 4185-1980.

### D. The flow metering system shall conform to the following:

- 1. Accuracy:  $\pm 0.2\%$  of flow rate from full scale.
- 2. Environmental Limits: - 20 to +60° C.
- 3. Power requirements: AC+ external battery with minimum 7 years life.

### E. The flow meter shall be furnished with the following accessories:

- 1. Furnish remote mount flow transmitter with a sufficient cable.
- 2. Provide stainless steel stanchions for mounting of remote transmitter no less than 4 feet above grade.
- 3. Provide manufacturer digital calibration verification unit with necessary accessories to interface with the furnished magnetic flow meter.

### F. 3G/3G Communications:

- 1. The magnetic flow meter shall be a battery operated, stand-alone water meter capable of 3G/3G communications using commercially available cellular data service. An external battery shall be supplied with the meter to extend service life to at least 7 years.
- 2. The magnetic flow meter shall also be capable of operating on 230 or 24 volts ac, 50 Hz. The meter shall be equipped with EEPROM memory to prevent data loss.
- 3. 3G/3G communications hardware shall allow the meter to transmit flow rate, totalized flow, pressure data, alarms and time-stamped stored process data over a third-party cellular network to the WBWD. The communications hardware shall be integral to either the flow meter or signal converter.
- 4. A high gain remote antenna shall be supplied with the meter that will allow data to be transmitted via 3G/3G technology.
- 5. 3G/3G modem must support Remotely commands for on demand data, on demand device health (Battery status, Battery Health, Flow rate, totalizer, etc...) and on demand actions by mean of SMS or by Email.
- 6. The 3G/3G module shall be programed to send the data once a day or as required by the Engineer.

### G. PRODUCTS:

**GENERAL:** The following paragraphs provide minimum device requirements.

#### I. Interconnecting Cable.

- 1. Interconnecting cable from the sensor to the transmitter shall be provided.
- 2. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter.
- 3. Length of cable shall be a minimum of 5 meters.

H. Integration with SCADA system.

- 1.1. The flow meters shall be capable to send data to the control room at WBWD office, Ramallah.
- 1.2. Flow meters shall be capable to be integrated with WBWD SCADA software and reporting system.
- 1.3. Must include lifetime software or tools to be integrated with SCADA and reporting system.

### **13.4 PRESSURE SENSORS/ TRANSMITTER**

The pressure detection will be performed by pressure sensors.

#### **13.4.1 CONSTRUCTION**

Pressure transducer level measuring equipment shall comprise a strain gauge or differential transformer type pressure transducer, a controller/transmitter and be complete with all necessary cable, conduits etc. as detailed below.

The pressure transducer shall be enclosed within an all welded, stainless steel case not less than 19.0 mm dia. and shall:

- Have a single moulded cable which is securely bonded to the transducer case and comprise electrical connections, venting tube, strain wire or cord and an outer covering of material suitable for the application.
- Be suitable for continuous immersion on all wastewater applications including raw sewage, primary sludge, secondary sludge and thickened sludge.
- Be constructed so that the sensor diaphragm is protected against damage by shock, debris etc., without restricting the transference of pressure changes from the surrounding medium.
- Incorporate automatic temperature compensation.
- Withstand a continuous overpressure of up to 400% without sustaining permanent deformation or calibration change.

The controller/transmitter shall:

- Be suitable for mounting within a control panel.
- Accept the signal from the transducer and provide a 4-20 mA output proportional to level (gauge pressure), for indication and control.
- Include independent zero and span adjustment.

The complete system shall:

- Operate with up to 100 m of cable between transducer and controller/transmitter.
- Provide an accuracy within  $\pm 0.1\%$  of the span with a linearity better than  $+0.1\%$ .

#### **13.4.2 INSTALLATION**

For installations where the sump depth is in excess of 3 m or where the available headroom over the sump is limited, the pressure transducer shall be installed within a 100 mm dia. GRP tube to provide protection against mechanical damage to both the transducer and the cable. The GRP tubing shall have an adequate number of holes and/or slots to allow it to fill and drain as the level varies. The tubing shall be fixed to the sump wall at intervals not exceeding 2.5 m.

For installations where the sump depth does not exceed 3 m, the sensor shall be supplied and installed as a rigid assembly comprising a stainless steel tube, a tube holder (both as used for control electrodes) and the transducer, with the cable passing through the tube. The transducer shall be a close fit located completely within the tube at the lower end. The assembly shall be fixed at not less than two places to the sump wall and installed with the bottom of the tube clear of the sump invert.

## **13.5 WATER LEVEL SWITCH**

The characteristics of the water level switch shall be the following:

- Sensor material: stainless steel 316L (1.4404 or 1.4435);
- Output: dry contact On/Off;
- Cable and sensor enclosure: IP68.

## **13.6 ULTRA-SONIC WATER LEVEL SENSORS**

### **13.6.1 CONSTRUCTION**

Where such equipment is specified in the relevant application Clause, level measurement shall be accomplished the use of non-contact, echo-time measuring equipment operating at ultra-sonic frequency. The equipment shall transmit pulses which are reflected back to the sensor from the surface of the liquid whose level is being measured.

The equipment shall consist of a sensor or transponder incorporating both transmitter and receiver, together with a separate control unit.

The equipment shall be provided with automatic temperature compensation shall be suitable for operation in the designated application under the climatic conditions.

The sensor shall be suitable for mounting in the open, or within an enclosed tank, and shall be totally enclosed and hoseproof with environmental protection to IP55 or IP67, as appropriate.

The control units shall incorporate facilities for adjusting independently both zero and span, and shall have an output of 4-20 mA proportional to level.

The overall accuracy of the level measurements shall be within  $\pm 0.1\%$  of the instrument span.

The connection between the sensor and control unit shall be via commercially available screened cable, and the equipment shall operate with up to 150 metres of such cable.

The Contractor shall ensure that each equipment, particularly with regard to the transmitted beam angle or cone and the blocking distance, is suitable for the application.

### **13.6.2 INSTALLATION**

The sensor shall be installed on a structure provided for the purpose. The structure shall have a square hole approx. 300 x 300 mm at the sensor mounting position.

Under this Contract, a stainless steel mounting plate of not less than 430 x 430 mm shall be provided. This plate shall be drilled to take the sensor and bolted securely to the civil structure. The Contractor shall ensure that, when bolted down, the mounting plate is exactly horizontal, so that the ultra-sonic beam will be perpendicular to the liquid surface.

The Contractor shall, where applicable, provide a canopy around and/or above the sensor and/or control unit to provide protection from direct sunlight.

## **13.7 PRESSURE GAUGES**

Gauges shall be provided having mounting arrangements, scale ranges, designation and alarm contacts as required. Gauges shall be of the Borden tube type with isolating diaphragm, brass case with flanged neck and stainless steel bezels. They shall have removable backplate to facilitate inspection and adjustment. Diameter of dial shall not be less than 100 mm. The dial shall be calibrated in kPa. Pressure range shall not exceed system working pressure more than 1.5 times. They will be supplied with their calibration certificate.

Each gauge shall be fitted with a stainless steel isolating cock.

Pump delivery pressure gauges shall be mounted directly on to the pressure tapping in the delivery mains and be corrected to show actual pressure at the delivery flange of the pump.

## **14 SCADA SYSTEM**

### **14.1 GENERAL**

The clauses in this section define the general requirements and standards of workmanship for the manufacture, supply, installation and commissioning of all SCADA equipment, and shall be applicable to these works.

#### **14.1.1 DESCRIPTION OF WORKS**

The purpose of this section is to describe the functionality of both SCADA systems to implement in WBWD system and Yatta system:

- In WBWD, a SCADA system already exists: the purpose of the present project is to update the SCADA with new data, to monitor flows.
- In Yatta system, there is no SCADA system: a new SCADA system shall be created for monitoring and control/command of valve chambers, reservoirs sites, and pumping stations.

The SCADA systems shall be implemented as operational management tool i.e. shall provide with facilities to undertake the day to day monitoring (and control/command for Yatta only) of the facilities and the production of general management information.

##### **14.1.1.1 SCOPE OF WORKS**

The Scope of works comprises:

- Supply, installation and commissioning of the Yatta SCADA control center workstation sized to monitor and control around 1000 database points, complete with:
  - Operating system
  - All necessary data storage devices
  - Printing devices
  - Furniture
  - Communication equipment and cabling for communication with the data loggers and PLCs equipment located throughout the network.
- Supply, installation and commissioning of the Yatta SCADA system software sized to monitor and control around 1000 database points
- Supply, installation and commissioning of the communications network including lightning protections units via a cable communication network for the PLCS.
- Supply of all necessary PLCs equipment.
- Supply, installation into electrical panels, interface to instrumentation signals and commissioning of PLC equipment.
- Supply of all necessary PLCs programming equipment, software and licences.
- Supply of all necessary data loggers equipment, software and licences.
- Configuration of the Yatta SCADA system database including programming of all data loggers and PLCs equipment to perform local control.
- Configuration of the WBWD SCADA system database including programming of all data loggers and PLCs equipment to perform local control.

##### **14.1.1.2 DESCRIPTION OF YATTA SCADA SYSTEM**

The system to be implemented shall be able to operate within the control strategy described in the following paragraphs but shall be flexible enough to be easily changed should the control philosophy change.

#### **14.1.1.2.1 SCADA System Overview**

The purpose of the new SCADA system is the following:

- Monitoring and Control/command on 3 reservoirs sites : Beit Amra, School Reservoir, Khalet Salem. The objective is to monitor flow and level within this project and control/command motorized valves for future.

#### **14.1.1.2.2 SCADA System Architecture**

The proposed architecture for the new SCADA system is described below.

##### **A. SCADA control-command center**

- 1 operator workstation (1 computer, 1 screen, 1 keyboard and 1 mouse) with 3 disks
- 1 firewall and VPN router for 3G system
- 1 UPS for the workstation
- 1 PLC for local data acquisition
- 1 A4 colour laser printer

##### **B. Local sites (pumping stations, reservoirs)**

For reservoirs sites the equipment will be the following:

- 1 PLC with 3G (3G) communication cards
- Deployed I/O modules
- 1 Human Machine Interface (HMI) integrated on the PLC or deployed
- 1 UPS
- 1 antenna 3G integrated to the 3G communication card or deployed

The Yatta SCADA architecture shall be design by the Contractor

#### ***Future SCADA architecture***

The measured data will be connected directly to the control center, to monitor instantaneous values (flows, pressures, levels, chlorine) and status in the control room.

The 3G (3G) connection should be of type VPN for data reliability, especially for control/command function.

The communication will be real-time.

#### **14.1.1.2.3 SCADA Control System Hardware**

A control center should be established in the Yatta municipality in Yatta to accommodate the SCADA system equipment and workstation.

The SCADA Control System equipment shall be as defined in chapter 2 here after.

Equipment for the control center shall be supplied and installed by the contractor and shall include:

- 2 no. flat top desks complete with integral cabling system and electrical sockets
- 1 no. lockable cupboard to be located beneath desk

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## PARTICULAR TECHNICAL SPECIFICATIONS

- 1 no. swivel chair with a duty of 8 hours continuous use

Equipment shall match.

### 14.1.1.2.4 SCADA Control System Software

This new Yatta SCADA system shall be fully compatible with existing WBWD SCADA system described here after that is to say: Yatta SCADA system should have a compatible software and same design philosophy as WBWD SCADA system.

For the period preceding the transfer of asset, a read-only access to the Yatta SCADA data should be implemented on the SCADA WBWD workstations or opposite if requested. After the transfer of asset, access and rights to the SCADA data could be modified according to new respective responsibilities of Yatta and WBWD.

### 14.1.1.3 DESCRIPTION OF WBWD SCADA SYSTEM

#### 14.1.1.3.1 Existing SCADA System Overview

A SCADA system was developed at WBWD in 2012-2013. This system was implemented under a project funded by USAID, and represents the first phase of the SCADA project. In this first phase, the SCADA functionalities was limited to monitoring. In the future, control-command is also to be developed.

The SCADA control center is located in WBWD office in Ramallah.

#### 14.1.1.3.2 Existing SCADA System Architecture

The architecture of the existing SCADA system is presented below. The details characteristics of the hardware are given here after.

**Table 14.1: Architecture of the existing supervision system**

LOCATION	SCADA SOFTWARE	RTU	MONITORED SITES	COMMUNICATION TYPE
Ramallah control center	ELUTIONS - Control Maestro 2011	SIEMENS SITRANS FM MAG 8000 FDK	Valve chambers	3G
		MOTOROLA ACE3600	Around 40 Wells 5 pumping stations (Tubas, Tamoun, Aqqaba, Meithalun, Rugib)	UHF/ microwave radio

#### 14.1.1.3.3 Existing hardware equipment

##### A. Servers

The SCADA system is composed of two cabinets installed in an air-conditioned room.

The first cabinet contains seven servers HP PROLIANT DL380p G8, type SFF with radio transmitter and firewall:

- SCADA Server-1 (Primary)
- SCADA Server-2 (Secondary)
- Historian
- System/Data Backup and Recovery
- Primary Domain Server

- Secondary Domain Server
- SCADA Web Server

The second cabinet, related to data transferred through 3G system, contains:

- A firewall Watchguard XTM 5 Series
- A switch HP 2530 48G
- Three servers HP PROLIANT DL360p G8 (two redundants and one historian).

**B. Control room**

The control room is composed of two SCADA operator workstations, one SCADA Web Client Workstation, completed by three screens and one large screen, and three printers. There is also one laptop connected to the SCADA located in the SCADA engineer office.

**C. RTU**

The PLCs of each well were re programmed during Phase 1 of the SCADA project and new RTU of type Motorola ACE3600 were integrated with.

WBWD uses electromagnetic flow meters equipped with transmitters from the same manufacturer. Each transmitter has two analogic inputs, for instantaneous flow and pressure if any.

NB: The total volume displayed on the workstations is a calculated value, based on the instantaneous flow.

**14.1.1.3.4 Existing SCADA control system software**

The software is Control Maestro 2011 developed by Elutions Inc. This SCADA software has an Object-oriented design. It delivers real-time and historical information and offers a Web-enabled remote access from anywhere via Internet and/or PDAs.

**14.1.1.3.5 Present Project content**

The scope of work of the SCADA component of the current project for the WBWD system is to connect to the SCADA 9 flow meters located in valves chambers or reservoir, for monitoring only. No motorized valve is required anywhere: as a result no remotely controlled valves are required.

The objective of the present design is to integrate seamlessly with the existing SCADA system the data newly obtained from the new or replaced flow meters. In some cases a pressure indicator should also be monitored (see detailed table here after).

WBWD requirements are the following:

- Automatic communication between flow meter and control center once per 24 hours
- Battery power with 5-year autonomy.

**A. Architecture**

The measured data will be connected directly to the control center in Ramallah, to monitor instantaneous flows, pressures and totalized flows in the control room.

To transmit data from flow meters and pressure indicators to the SCADA control center, data loggers or PLCs (depending on site characteristics, see detailed table in paragraph 0) should be supplied, installed and commissioned under this contract.

**B. Communication**

It is required to use 3G (3G) communication system between the flow meter chambers and the control center. The connection should be of type VPN.

The capacity of the HP PROLIANT DL360p G8 servers is sufficient to integrate the new monitored data.

**C. From Historical system to real-time system**

The time stamping at source of data could be integrated in the existing software for some specific communication protocols (for example: Softbus). The new equipment should use one of those protocols; otherwise it will be necessary to use an OPC server.

**D. Data loggers and PLCs**

The data loggers shall have as a minimum the following features:

- 4 Digital Inputs for counting, and alarms (battery, flooding and intrusion), with dry-contact acquisition.
- One or two Analogic Inputs (as per above detailed table) enabling acquisition of 4-20 mA signals, which could be powered directly by the data logger.
- Integrated 3G (3G)Communication Cards
- 7-year autonomy lithium battery.

**14.1.2 WORKS INCLUDED FOR THE TWO SCADA CONTROL CENTERS**

**14.1.2.1 MIMIC DISPLAY**

They will include all mimics listed below.

All mimics shall be suitable for display all sizes of monitor supplied within the contract and careful design of the mimic shall be used to this end. Where mimics replicate those configured for the local PLC display, the mimics shall be identical to those displayed on the PLC display.

The following requirements are required for all mimics:

- The background colour for all mimics shall be subject to the approval of the Engineer.
- Each mimic shall have navigation “pushbutton” to the process overview, the geographical overview and associated process mimics.
- The symbols used to describe the water supply network items shall be subject to the approval of the Engineer.
- Mimics shall display process lines as colour dynamic with arrow indication of flow direction.
- Alarms indication shall be animated within the relevant mimic.
- Trend pages (including historic and current information) and the alarm summary page shall be available from every mimic.
- Each on-site workstation shall be configured such that a screen dump can be printed by a single keyboard/on-screen action.
- Control pages for all equipment that can be controlled, overridden or equipment data entered manually shall be available for every mimic.

**A. Yatta Mimics**

The contractor shall create the following mimics:

- 1 mimic per reservoir sites : Beit Amra, School Reservoir, Khalet Salem.

TOTAL: 3 mimics

**B. WBWD Mimics**

The contractor should create 1 new mimics per chamber/ reservoir to integrate the new flow meter readings, that is to say 9 new mimics in total.

#### **14.1.2.2 ALARM FACILITIES**

The alarm list shall be configured in accordance with the following Chapter 2. The colours used to describe the state and priority of each alarm shall be subject to the approval of the Engineer.

The facility shall be fitted to enunciate user definable alarms that have been accepted within a user definable period via the klaxon and lights associated with each control panel. The klaxon and light at each panel shall be reset on acceptance of the alarm.

#### **14.1.2.3 HISTORIC INFORMATION**

The SCADA system will save automatically the current day's historic data and delete any data greater than 365 days old at midnight. The facilities shall be provided to recover data greater than 365 days old from the archive device.

#### **14.1.2.4 REPORT GENERATION**

##### **A. Yatta reports**

The contractor should configure 10 no. simple reports proving statistical information relating to the performance of the water supply utility. The content of the reports shall be subject to the approval of the Engineer.

##### **B. WBWD reports**

The contractor should configure at least 10 no. simple reports proving statistical information relating to the performance of the water supply utility. The content of the reports shall be subject to the approval of the Engineer.

#### **14.1.2.5 SCADA SYSTEM DATA BASE CONFIGURATION**

The Contractor shall configure the SCADA database to include all input/output requirements. This shall include, but not be limited to:

- Descriptions.
- High, High-High, Low-Low and Low alarm levels.
- Alarm text.
- Alarm priorities.
- Dead-bands.
- Persistency (How long the signal must be in alarm condition before alarm is raised).
- Historic data for trending of inputs etc.
- Scanning intervals.

The following shall be saved to disc, for display on the SCADA system:

- Pressure readings,
- Flow meter readings in valve chambers and on reservoir and pumping station sites,
- Total flows (per hour, day, month and year),

And for Yatta only:

- Level readings,
- Chlorine readings,
- Hours run for pumps.

#### **14.1.2.6 SYSTEM RESPONSE TIMES**

The equipment supplied within this contract shall satisfy the response times as detailed within the following Chapter 2.

### **14.1.3 OTHER RELATED WORKS INCLUDED**

#### **14.1.3.1 COMMUNICATION MEDIA**

Communication between workstation and peripherals will have to use Ethernet media.  
Communication between central units and PLCs will have to use 3G (3G) communication system.  
Communication between PLC and Deported I/O Modules will have to use Ethernet media.

#### **14.1.3.2 LOW VOLTAGE PROCESS DISTRIBUTION (LVPD)**

For operation of the drives each motor starter shall be equipped with a Selector Switch "Manual/ Auto" and pushbuttons.

In "Manual" mode the drive can be operated via pushbuttons independent from the PLC.

#### **14.1.3.3 OPERATING LEVELS**

##### **14.1.3.3.1 Field control station (local)**

The field control station (in valve chambers or on reservoir or pumping station sites) has the highest priority. The station shall be equipped with a selector switch "Local/Off/Remote" and an adequate number of push buttons to operate a drive.

In "Local" mode the drives can be operated locally via push buttons. All other control levels shall be disabled. Protection interlocks shall be hard-wired and remains operation.

The field control stations shall be located in the vicinity of the equipment.

Each drive shall be equipped with a separate emergency lock stop pushbutton, which is hardwired directly into the drive contactor control circuit.

##### **14.1.3.3.2 PLC – SCADA (Supervision Control and Data Supervision) and LVPD Control**

If the selector switch at the field control station is set to "REMOTE" and,

- The selector switch at the LVPD is set in "AUTO", the operation from the corresponding PLC in automatic or in manual mode by SCADA shall be possible.  
Start/Stop/Open/Close/Over-ride/Inhibit will be possible via SCADA.
- The selector switch at the LVPD is set in "MANUAL", the operation from the LVPD in manual mode shall be possible.

By switching from automatic to manual the drives shall hold the actual state of operation, i.e. an operating drive keeps on running, a switched off drive is not started.

#### **14.1.3.4 HMI (HUMAN MACHINE INTERFACE)**

Each PLC shall be equipped with an operator interface. Mimic page reflecting the current status and values of the equipment to which the PLC is interfaced.

Also modifications such timers, counters or other parameters shall be possible.

#### **14.1.3.5 ALARM AND SWITCHING POINTS**

The alarm and switch points can be adjusted at the operator work stations of the SCADA-System. Permission of access levels can be defined, to prevent unauthorised adjustment.

Alarms will be shown at the mimic page of the SCADA-System. Unacknowledged alarms are shown with flashing pulses and with acoustic signal. After acknowledging, the alarms are shown steady and the acoustic signal stops.

The alarm will be also printed out on the alarm printer at the Control Centre.

For restart of the pumps/drive the alarm will have to be reset.

#### **14.1.3.6 CONTROLLER**

All controllers will be implemented in the PLC. The set points for these controllers can be adjusted at the operator panel.

If automatic control is not possible, an alarm will have to be indicated.

#### **14.1.4 SUBMITTALS**

The Contractor shall submit a Functional Design Specification (FDS) to be approved by The Engineer prior to manufacture and purchasing of equipment.

The FDS shall be submitted in English and the national language of the Purchaser on A4 size sheets numbered within each section and page within section, to include, but not limited to, the following for each valve chamber, reservoir or pumping station to be monitored:

- Content List.
- Relevant details of associated mechanical, electrical and instrumentation equipment.
- Design documentation, including:
  - A description of each major element of the control scheme.
  - A flow-chart or pseudo-code description of each sequential element of the control scheme.
  - Analysis of failure modes and shutdown procedures.
- Calculations.
- Quality control procedures and approvals.
- Outline of test procedures.
- Manufacturer's literature for each item of equipment supplied.

All drawings shall be on A4 or A3 sized paper as appropriate to ensure legibility include a title block detailing:

- Purchaser's Name.
- Contract Title.

- Contractors Name.
- Drawing Title.
- Drawing Number.
- Date.
- Author.
- Verification and approval by the Contractor prior submission.

#### 14.1.5 NETWORK PRESENTATION

##### 14.1.5.1 DETAILED FUNCTIONAL DESCRIPTION

###### 14.1.5.1.1 PLC – Reservoirs

- Used materiel:
  - US level sensor
  - Electromagnetic flow meter at reservoir inlet
  - Electromagnetic flow meter at reservoir outlet
- Function:
  - Continuous operation of a set of continuous measurement of level and flow
  - In future Open/close reservoir inlet/outlet
- Automatic functioning:
  - Continuous measures by US level sensor and flow meter

###### 14.1.5.1.2 Data logger - Valve chambers

- Used materiel:
  - Pressure sensor
  - Electromagnetic flow meter
  - Chlorination sensor to measure chlorination rate
- Function:
  - Continuous operation of a set of continuous measurement of pressure, flow and chlorination rates with chain of local indication and remote
- Automatic functioning:
  - Continuous measures by pressure sensor, flow meter and chlorination sensor.

##### 14.1.5.2 INPUTS/OUTPUTS REQUIREMENTS

###### 14.1.5.2.1 PLC – for each reservoir

<i>LOCATION</i>	<i>EQUIPMENT</i>	<i>NUMBER</i>	<i>Di</i>	<i>Ai</i>	<i>Do</i>	<i>Ao</i>
Beit	Flowmeter (Nb)	2	2	2		

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LOCATION	EQUIPMENT	NUMBER	Di	Ai	Do	Ao
Ammra	Level meter (Nb)	1		1		
	<b>TOTAL</b>		<b>2</b>	<b>3</b>		
LOCATION	EQUIPMENT	NUMBER	Di	Ai	Do	Ao
School Reservoir	Flowmeter (Nb)	2	2	2		
	Level meter (Nb)	1		1		
	<b>TOTAL</b>		<b>2</b>	<b>3</b>		
LOCATION	EQUIPMENT	NUMBER	Di	Ai	Do	Ao
Khalet Salem	Flowmeter (Nb)	2	2	2		
	Level meter (Nb)	1		1		
	<b>TOTAL</b>		<b>2</b>	<b>3</b>		

### 14.1.5.2.2 Data logger Valve chambers of WBWD utility

NO.	CHAMBER NAME	DESCRIPTION	NEW CHAMBER	ANALOG INPUT	NOTE
1	Ziif 1	Underground Chamber	Yes	2	-
2	Ziif 2	Underground Chamber	No	2	-
3	Al Reyhia 1	Underground Chamber	Yes	2	-
4	Al Reyhia 2	Underground Chamber	Yes	2	-
5	Beit Ammra Connection	Underground Chamber	Yes	2	-
6	Samoo'	Underground Chamber	Yes	2	-
7	Beit Ammra Inlet	Above ground	Yes	2	-
8	Shcool Inlet	Underground Chamber	Yes	2	-
9	Khalet Salem Inlet	Underground Chamber	Yes	2	-

### 14.1.6 STANDARDS

The works for control and supervisory systems shall be designed, manufactured and tested according to the relevant codes, standards, rules, and regulations as listed below, all in latest valid edition.

In case of any inconsistency or conflict exists between the different specifications, codes, forms or drawings and standards, the more restrictive shall be applied.

- IEC 21989 : Information technology - Telecommunications and information exchange between systems - Private Integrated Services Network - Specification, functional model and information flows - Short message service.

## COMPLEMENTARY WORKS OF YATTA WATER SUPPLY SYSTEM PARTICULAR TECHNICAL SPECIFICATIONS

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- IEC 21990 : Information technology - Telecommunications and information exchange between systems - Private Integrated Services Network - Inter-exchange signalling protocol - Short message service.
- IEC 60068 : Environmental testing – All Parts.
- IEC 60870 : Telecontrol equipment and systems – All Parts.
- IEC 61000 : Electromagnetic compatibility (EMC) – All Parts.
- IEC 61010 : Safety requirements for electrical equipment for measurement, control, and laboratory use – All Parts.
- IEC 61131 : Programmable controllers – All Parts.
- IEC 61326 : Electrical equipment for measurement, control and laboratory use – EMC requirements – All Parts.
- IEC 61784 : Industrial communication networks - Profiles – All Parts.
- IEC 61850 : Communication networks and systems for power utility automation – All Parts.
- IEC 62008 : Performance characteristics and calibration methods for digital data acquisition systems and relevant software.
- BS 5887 : Code of practice for testing of computer based systems.
- BS 6238 : Code of practice for performance monitoring of computer based systems.
- BS 6739 : Code of practice for instrumentation in process control systems - installation design and practice.

## **14.2 PRODUCTS**

### **14.2.1 GENERAL**

The requirement for a SCADA system is detailed in the following sections.

### **14.2.2 SYSTEM OVERVIEW**

A control centre shall be established in a location defined in above part 1, to accommodate the SCADA equipment and operator workstations.

The system implemented shall be able to operate within the control strategy described but shall be flexible enough to be easily changed should the control philosophy change.

The proposed system shall provide:

- A centralised processing function, complete with standby facilities and local workstations.
- Distributed intelligence using microprocessor based Programmable Logic Controllers (PLCs) for monitoring and data logging. Under normal operating conditions, the PLCs shall monitor and control/command facilities and record the facilities operational/performance data.
- The PLCs shall have programmable alarm limits for discrete and rate of change settings. This shall apply to both real and derived values. There shall be a possibility for high and low priority alarms, e.g. low, very low, high and very high.

In order to cater for communications failures, the data loggers and PLCs shall be capable of holding 8 day worth of data as follows:

- Analogic totalised and derived signals - on significant change/15 minute intervals.
- Digital signals on change of state.
- The data gathered from the data loggers and PLCs shall be incorporated into the SCADA control center database and shall also be made available to applications programs written by the client.
- Where PLCs are programmed to perform local control it shall be possible for the programmes, schedules, set-points etc. to be downloaded from the SCADA control center. Subject to being assigned suitable privileges, system users shall have the possibility to make short term alterations to PLC control schedules via the control centre, e.g. to implement remedial action when an alarm occurs.

SCADA Control shall be performed at two levels, these being:

- PLC local control via programs stored locally at the PLC, e.g. pump start and stop, fallback control.
- Supervisory control from the control centre. An authorised user, at the control centre shall be able to modify the control routines at any PLC by downloading new control (start/stop) schedules, new performance criteria e.g. increase/decrease flow/pressure or operating individual items of the water supply system e.g. open/close valve, start/stop pump.
- There shall be a requirement to download control programs and schedules to the PLCs from the SCADA control center via the communications network.
- The preferred method of communication with site based data loggers and PLCs is 3G system.
- The system shall operate using 'management by exception' techniques. The data logger or PLC shall monitor and control the site and record operational data. When an alarm condition is detected the data logger or PLC shall dial into the master station immediately

to announce the alarm and forward any data collected. Where alarm conditions arise, individual alarm presentation with alarm lists, mimic and tabular diagrams, and help pages shall be available to assist the operator.

### **14.2.3 SCADA CONTROL COMMAND CENTRE**

#### **14.2.3.1 GENERAL**

A centralised SCADA Control Command Centre shall be provided for the SCADA system unless otherwise specified within the particular specification.

All equipment required to fulfil the requirements shall be industry standard proven computing equipment with a demonstrable long-term life cycle and support.

To permit other manufacturer's equipment, e.g. data loggers and PLCs, to be added to the SCADA system, all equipment shall, wherever possible, interface using open-system communications protocols.

#### **14.2.3.2 SYSTEM AVAILABILITY**

##### **14.2.3.2.1 general**

The strategic importance of the SCADA system requires a high level of system availability, i.e. not less than 99.9% availability for each calendar year. The SCADA system shall therefore be provided with the following.

##### **14.2.3.2.2 hot standby**

The system shall be capable of operating with a master and standby workstation where the standby workstation shall be continually updated and automatically assume responsibility within 30 seconds following failure of the master workstation.

Synchronisation of the databases following system recovery shall be automatic i.e. shall not require manual intervention.

##### **14.2.3.2.3 uninterruptible power supply (ups)**

The system shall be provided with a UPS capable of supporting all the main computer equipment (central processing units, discs, communications processors etc.), operating consoles and printer for a period of not less than 4 hours. The UPS shall be provided to cater for a 50% increase in load without the need for additional hardware.

Note: Essential services, e.g. UPS, generator and security etc. shall be monitored by the SCADA system.

##### **14.2.3.2.4 maintenance**

The SCADA control center equipment shall be subject to an annual and renewable maintenance contract where a competent engineer shall attend site within 24 hours from the time the failure was reported, twenty four hours a day, 365 days a year.

##### **14.2.3.2.5 communications equipment**

The SCADA control center equipment shall be provided with all necessary communications equipment to support:

- All operator workstations.
- All printing devices.
- The communications network comprising:

- Communications to all on-site data loggers and PLCs.
- All remote equipment.

#### **14.2.3.2.6 data storage**

Each master station shall be provided with the following storage media:

- Random Access Memory – to store the “real-time”/instantaneous database.
- Hard discs – to store the system configuration, mimics and local short-term (70 days) historical database etc.:
  - Digital points on change of state.
  - Analogue points at 15 minute intervals.
  - Derived points.
- Optical disc - to store off-line (greater than 70 days old) historical database, system backups, data transfer etc.
- DVD burner- to transfer data to off-line PC equipment.

#### **14.2.3.2.7 Operator Workstation**

- **General**

The computer hardware of the SCADA control center shall be constituted according to necessary characteristics for the smooth running of the SCADA, but at minima for a workstation of:

- 1 Central unit.
- 1 QWERTY keyboard.
- 1 LCD 24" Full HD screen.
- 1 A4 color printer.
- 1 optical mouse with programmable buttons and thumb wheel of navigation.

- **Central unit**

The central unit shall have the following characteristics at minima:

- Type : Intel Core 2 Duo 3,0 GHz.
- 16 Go de RAM.
- 2 DD SATA de 156 Go unitary.
- Windows Server 2012 + Office Pro 2013
- Engraver DVD + RW DL SATA.
- Integrated sound card + microcomputing and Loudspeaker..
- 1 Ethernet port.
- 3 RS232 ports.
- 2 LPT ports.
- 10 USB ports.
- Integrated remote maintenance modem.

- **Human-Machine Interface (HMI)**

The operator workstation shall be the main Human-Machine Interface (HMI) and shall consist of 24 inch (minimum) Visual Display Units (VDUs) capable of displaying graphical and alphanumeric characters in at least sixty-four colours in all foreground/background combinations.

- **Key board**

The VDU shall have an associated keyboard consisting of a standard typewriter QWERTY alphanumeric set, with additional numeric and special function keys, augmented by a mouse or tracker-ball.

- **printing devices**

The system shall be provided with one colour laser Printer to a hard copy log of all alarms and significant events (with colours to differentiate alarms and level of alarms from events), e.g. operator sign-on or control override and to provide high quality printed output for report summaries, programme development, copies of mimic displays, historical trends. The printer shall be capable of 10 ppm (colour).

- **Data transfer**

The SCADA system shall be capable of processing the data received from operational sites e.g. into daily minimum, maximum and means, and forwarding the raw and processed data to off-line packages e.g. Microsoft Excel.

#### **14.2.4 SCADA SYSTEM FEATURES**

##### **14.2.4.1 GENERAL**

The Employer requires a low risk system supplied with proven software to be agreed by the Engineer. The new Yatta SCADA system and existing WBWD SCADA system should be fully compatible all together.

##### **14.2.4.2 SYSTEM ACCESS**

Users of the system shall be allocated individual passwords allowing each user an appropriate level of access commensurate with their requirements, responsibilities and areas of knowledge and interest.

Three general categories of access have been identified:

- Data only.
- Data and Control/Command.
- Data and programming (Administrator level).

Data only shall be generally available to all system users. Data and control shall be limited to those personnel with the knowledge and responsibility to take control actions.

The Contractor shall hand out all required license, password, etc. to let the owner do all required updates, maintenance in future.

##### **14.2.4.3 COLOUR GRAPHICS DISPLAYS**

The following display types shall be all available on colour graphics:

- Mimic diagrams.
- Help pages.
- Graphs.

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- Bar charts.
- Alarm and event log listings.
- System configuration and maintenance displays.

### 14.2.4.3.1 mimic diagrams

Mimic diagrams are required to present a pictorial representation of the water supply system and its present status. Features required are as follows:

- Display of fixed (background) diagrammatic water supply system information and text.
- Display of variable information i.e. symbols or text displaying water supply system status (auto/remote/manual, on/off, open/close/torque, fault) or analogue (flow, pressure, chlorination rate, level).
- Easy picture creation, possibly using a CAD style package.

### 14.2.4.3.2 display of variables

Variables can be considered as digital on/off parameters, analogue or totalizers.

Digitals may be either status (e.g., running/stopped) or alarm points, and shall be displayed by:

- Text changing.
- Symbol colour changing.
- Symbol shape changing.
- Text or symbol flashing.

It must be possible to associate more than one digital point with a symbol, so that more than two colours/shapes can have operational meaning. For example, a pump may be shown in four colours indicating running/stopped/failed/non-operational.

In addition, it shall be possible to associate any number of symbols within different mimics with a particular digital point.

Analogues and totalizers shall be displayed by:

- Numeric value.
- Bar chart.
- Graph.

It shall be possible to display all these three types of indication in mimic diagrams. Colour changes shall be used to indicate further information about a point, e.g. if an alarm limit has been exceeded.

### 14.2.4.3.3 display attributes

Using the display facilities described above, the mimic diagrams shall indicate the following attributes for analogue, digital and totalizer points:

<u>Attribute</u>	<u>Point Type</u>
Status On/Off	Digital Status
Alarm/Normal	Digital Alarms
1 <sup>st</sup> Stage Alarm (High, Low)	Analogues
2 <sup>nd</sup> Stage Alarm (High-High, Low-Low)	Analogues

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Communications Failure	All
Alarm Manually Suppressed (out of service)	All
Alarm Automatically Suppressed	All
Out of Range	Analogues

#### 14.2.4.3.4 pictures creation

It is essential that picture creation is a straightforward procedure, a CAD type package should be necessary. It must be possible to create symbols which may then be used in any orientation, size and colour and to create a symbol library, i.e. a part of a diagram which may then be used many times. It must be possible to display, on any single mimic diagram, information from anywhere within the system.

#### 14.2.4.4 HELP PAGES

Help pages shall be available within the system, to assist the operators in dealing with received alarm conditions. These pages will be compiled by the water supply system managers and will provide advice as to which staff shall be notified of which alarms.

Help pages may be presented as individual pages accessed from a mimic, or as a window superimposed on a mimic.

#### 14.2.4.5 GRAPHS

Graphical representation of historical data is required, with a selectable time base and the ability to put up to four graphs on display at once on the same axes, using different colours.

The system must be easy to use, with automatic default facilities so that only a minimum of instructions need to be given to the system to obtain each plot.

Features that will be required are:

- Pre-configured and ad-hoc trend displays.
- Ability to compare graphs over different time spans, e.g. today's flow compared against yesterday's flow.
- Read-out of the actual value of a graph at a given time point.
- Ability to roll a graph forward and backwards in time.
- Ability to set the scale for each graph.
- Trend graphs giving a plot of the selected variable up to the last scan, updating when a new value is received.
- Ability to incorporate a trend graph as a feature on a mimic diagram.
- Graphical output of both analogue and digital signals (real and derived). Digital signals will produce a square wave type plot indicating for instance when a pump started and stopped.
- Auto ranging scale unless manually overridden.
- Ability to display data from different sites within the same trend display.

#### 14.2.4.6 BAR CHARTS

A bar chart type representation of analogue variables is required. This is required on mimic diagrams, and must be capable of horizontal or vertical orientation, with selectable scaling. Width of bars must be selectable so that the feature can also be used for such items as tank level pictorial representations.

#### **14.2.4.7 ALARM AND EVENT LOG LISTINGS**

All alarms and changes of status (i.e. digital events) in the system shall be logged to disc. It shall be possible to recall this information to the screen via a select and sort programme. This programme shall sort and display information on at least the following bases:

- Site type.
- Site name.
- Time period.
- Signal identification numbers.
- Signal state (on/off).
- Alarm status i.e. cleared, accepted and unaccepted.
- Alarms or status occurrences required.

Any sort parameters not entered shall default to "all".

#### **14.2.4.8 SYSTEM SET-UP AND MAINTENANCE DISPLAYS**

Suitable displays of information shall be provided to display all set-up features of the system. These displays will be closely associated with the SCADA system set-up facilities.

#### **14.2.4.9 LOGGING ON/OFF**

Every user of the SCADA system shall be required to log on (i.e. activate) his terminal when he wishes to operate on it. The system shall be aware of which terminals are logged on and the access rights of the user and shall therefore be aware of where to send certain information.

#### **14.2.4.10 ALARM FACILITIES**

##### **14.2.4.10.1 general**

Digital points within the system shall be capable of operating as either status (e.g. running/stopped) or alarm points (e.g. normal/failed). A digital alarm point shall enter the Alarm State when it is either a logical '1' or logical '0' as designated in the system set-up for each point, the opposite state being the normal condition.

Analogue points shall be provided with two high alarm limits (high and high-high), and two low alarm limits (low and low-low). Should an analogue value either rise or fall from a value considered to be normal, a first stage high or low alarm limit will be encountered resulting in a new alarm condition. Should the value continue to rise (or fall) it will then encounter the second stage high-high or low-low alarm limit again resulting in a new alarm condition.

##### **14.2.4.10.2 alarm priorities**

Every alarm generated within the system shall be allocated an alarm priority to indicate the importance of the alarm. Whereas a digital point shall have only one alarm priority, an analogue point shall have three. This shall allow the relative importance of the first and second stage high and high-high (low and low-low) alarms to be set. The alarm priority is used in conjunction with the 'area of interest' of the users logged onto the system to determine where and when a new alarm is enunciated. The priority of an alarm shall change if required depending on the time and date.

#### **14.2.4.10.3 alarm annunciation**

Alarms are to be enunciated on the operator workstation both visually and audibly, and have clear and unambiguous acceptance procedures. High priority alarms shall be presented for acceptance before low priority ones.

#### **14.2.4.10.4 alarms filtering**

The SCADA system shall have a “tool-kit” of facilities that may be applied to individual points in the system in order to prevent unnecessary annunciation of alarms. These shall typically include:

- Analogues:
  - Dead Band.
  - Delay before initial alarm.
  - Minimum alarm repeat interval.
  - Logical suppression of new alarm if other conditions are presents.
  - Averaging values in PLC.
- Digitals:
  - Delay before initial alarm.
  - Minimum alarm repeat interval.
  - Logical suppression of new alarm if other conditions are presents.

Users, subject to authorisation (i.e. correct level of access), shall be able to manually suppress an alarm, e.g., if a transducer is faulty and is being particularly troublesome. The suppression of alarms shall be logged to the event list.

#### **14.2.4.10.5 derived alarms**

A combinational and sequential logic package is required within the SCADA system, allowing signals to be combined to form derived alarms. These may be combinations of analogue and digital information obtained from different sites (e.g., a pump may be running at a pumping station but no flow entering the associated inlet works resulting in a derived alarm indicating a potential burst).

#### **14.2.4.11 HISTORIC INFORMATION**

##### **14.2.4.11.1 data loggers and PLCs**

Data loggers and PLCs shall sample and store values of analogue parameters at 15 min intervals to cater for loss of communications. But it shall be user configurable between 1 minute and 24 hour intervals.

##### **14.2.4.11.2 Master Workstation**

In addition to the raw operational data, a long-term archive of analogue hourly max/min/mean values, pump hours run, valve status, alarms and operator actions (cf. paragraph 14.2.4.14) shall be maintained.

#### **14.2.4.12 CONTROL / COMMAND**

##### **14.2.4.12.1 manual control / command**

It shall be possible to perform control / command operations (e.g. remote start/stop of pump) from any of the operator consoles. Access to controls shall be limited by the access rights assigned to the individual passwords for various operatives (see System Access).

The issuing of control instructions shall take precedence over the scanning for alarms.

A well organised select check and execute system is required.

#### **14.2.4.12.2 automatic control / command**

Automatic control / command features shall be available within the SCADA system, and fall into two categories:

- Profile type controls where a working pattern (e.g. of reservoir level) is downloaded to a PLC for use by a local control system. New profiles may be sent for each day or week etc., as required.
- Combinational and sequential control / command:

There are circumstances where the only practicable way of closing a control loop is via the SCADA system, although this should be avoided whenever possible. The package used for alarm derivation shall also fulfil the automatic control requirements. The following facilities shall be provided as a minimum:

- Logical AND/OR/NOT/EXOR/EQUALS.
- IF-THEN-ELSE Constructions.
- Arithmetic operations including >, \$, >, #, =, +, -, H, ), /.
- Logical constructions including time and data.
- Look-up tables, with interpolating facilities.
- Input to functions from any system point including digital, analogues, totalizers, controls from a keyboard, set-point input from a keyboard.
- Output from functions to be available as digital, analogue or totalizer points, or transmitted to any PLC as a control or set point.
- Access to point attributes in addition to present value, including:
  - Suppressed, telemetry failed, in alarm (and for analogues, which alarm level).

#### **14.2.4.13 TERMINAL TIME OUT**

When a terminal (workstation or PLC) is used for control/command purposes, it shall have to be logged on specifically for that function. If it is not used for a user configurable period of time (e.g. 5 minutes) in this mode, it shall automatically revert to a display only mode. A warning should be provided one minute prior to the auto log off.

#### **14.2.4.14 SYSTEM RECORD**

A record shall be kept on disc within the system of all operator actions, such as alarm acceptance or control actions performed on the system. The record shall include:

- Time and date.
- Action.
- Operator.

This record shall be retrievable from the system using a similar select and sort routine to that specified for status and alarm logs.

#### **14.2.4.15 REPORT GENERATION**

The system shall be capable of generating both regular and individual reports. Reports must be easily configured and altered in order to maintain their relevance.

An example of a regular report which may be produced from the system is the following, designed to be made available to the works manager each morning:

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- Flow measurement: minimum, maximum and means of last day.
- Alarms that have occurred during the night.

### 14.2.4.16 SYSTEM TIME

The system shall support:

- Greenwich Mean Time (GMT/UCT).
- Daylight Saving Time (DST).
- Leap Years.

All data shall be logged at GMT/UCT + 2 hours, but automatically displayed in the appropriate local time adjusted for daylight saving.

### 14.2.4.17 SYSTEM DATA CONFIGURATION

The system shall be provided with privileged and secure on-line database building utilities i.e. it shall not be necessary to stop the scanning and alarm presentation facilities. Any configuration shall not be installed into the active database until completed, verified and authorised by the user. A reliable verification procedure shall be required to prevent the creation of invalid files and the deletion of in-use files.

It shall be possible to define process point files, calculated/derived point files, remote PLC files, to include:

- Meaningful point identification and description.
- Allocation of points to groups/locations.
- Range of analogue values in Engineering Units.
- Alarm limits/categories.
- Scan control/frequency.
- Report control (whether change of state is to be logged to the alarm/event printer).
- Save control (whether values are to be archived).
- MIS control (whether values may be transferred to other systems).

### 14.2.4.18 SYSTEM RESPONSE TIMES

The SCADA control center provided under this contract shall meet the following performance criteria:

Item	Description	Response (seconds)
1	From change of state being detected by data logger or PLC	0.5
2	From change of state being detected by the SCADA control center to updating the SCADA database	0.5
3	From change of state in the SCADA database to updating the alarm list	0.5
4	From change of state in the SCADA database to updating the active mimic	0.5
5	All requests for mimic displays, alarm lists and help pages from the completion of the operator request.	3

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6	All requests for trend displays and event lists from the completion of the operator request.	10
7	Time to perform screen dump from completion of the operator request	30

### 14.2.5 DATA LOGGER EQUIPMENT

The data loggers should be installed in closed cabinets next to related measurement equipment (pressure indicator, flow meters, and chlorine sensors) or in the chambers in which the measuring equipment are installed.

#### 14.2.5.1 GENERALITIES

The data loggers should be compact products, with integrated or deported 3G antenna and lithium battery such as to get power autonomy for several years (2 years at minimum in real-time use and 5 years at minimum in other case).

To meet the requirements related to the rugged environment in which the data loggers are generally installed (external cabinet or underground chambers), the data loggers should be IP68 certified.

In case data loggers are installed with external antenna, this one should also be IP68 certified.

The data loggers should be specifically designed to address the followings:

- Constraints experienced on works : robustness, sealing, power autonomy
- Users requirements in terms of operation : efficiency and user-friendliness for implementation and use

#### 14.2.5.2 DATA ACQUISITION AND RESTITUTION

- The data loggers should have digital and analogue inputs:
- Digital inputs to detect flooding and intrusion in the manhole, power supply fault and flow counting: 4 digital inputs to enabling dry contact acquisition.
- Analogue inputs for flow, pressure and chlorine measurement if any: 2 or 3 analogue inputs, enabling acquisition of 4-20 mA signals, which could be powered directly by the data logger (8V or 12V).
- After signal acquisition from a sensor (pressure sensor, flow meter, chlorine sensor), the following treatments are performed:
  - For the digital inputs signals (or alarms): call the SCADA control center and a mobile phone through SMS (alert function).
  - For the digital inputs counts: impulse count with the possibility to have two-way counting, mean flow calculation, minimum and maximum daily flows, and other calculations (daily index variations, for example for night flows). Those data could be archived each 5, 10, 15, 30 or 60mn.
  - For analogue inputs: archiving, basic calculations (minimum and maximum). Those data could be archived each 5, 10, 15, 30 ou 60mn.
  - For each analogue value, 4 thresholds could be defined. A threshold overrun could trigger an alarm at supervision level. These alarms could be delayed, to avoid short time phenomenon. A SMS could also be sent on operator mobile phone (alert function).

#### 14.2.5.3 TRANSMISSION TO THE CONTROL CENTRE

- The data loggers should be able to send once a day by SMS the archived values and calculation results to the control center. The time of the daily call should be configurable. To reduce the number of SMS, compressed format should be available (for example: 1 SMS per day for a meter and mean flow archived each 15 min).

#### 14.2.5.4 TIME SETTING

- To ensure a perfect consistency to the data, the data loggers should be synchronized at their internal clock level, with automatic time setting.

#### 14.2.5.5 CONFIGURATION AND READING TOOLS

- Configuration tool:
  - The laptop will be the configuration tool. It shall be equipped with a dedicated software from the manufacturer. This software should mainly use a graphic interface, user-friendly to facilitate a quick and safe data logger configuration.
  - The configuration data between laptop and data logger could be made locally through Bluetooth or remotely through the sending of SMS.
  - The software should be able to read and save the configuration installed on each data logger and so to duplicate any configuration from one data logger to another one.
- Reading tool:
  - Beside the configuration tool which will enable access to the data (reading), it shall be possible to read the data as follow:
    - Locally: by using a laptop or pocket laptop equipped with Windows Mobile and a Bluetooth port, enabling reading of pressure, flow and meter values but also some diagnostic functions detailed below.
    - Remotely: through the sending of SMS from a mobile phone with 3G system. Those messages would give the values and parameters of the logger. The mobile could also be used for some diagnostic functions detailed below.

#### 14.2.5.6 DIAGNOSTIC TOOL

- To facilitate installation of products on site, and the diagnostic in case of failure, the data loggers shall be equipped with LED lights to:
  - Check that the logger could operate
  - Check that the SIM card is operational
  - Check the GSM signal strength
- To get a more accurate diagnostic, it must be possible to use a laptop or pocket laptop equipped with a Bluetooth port. This wireless connection shall enable to work outside from the manhole. It shall enable at minimum the following functions:
  - Read the current status and values (counts, signals, measures), battery status
  - Test the communication or search for the GSM operator having the best coverage on site

#### 14.2.5.7 MAINTENANCE

- **Battery replacement:**

- To facilitate the maintenance, it should be possible to carry out easily the battery replacement, without specific equipment and while maintaining the sealing of the product.
- **SIM card replacement:**
  - Similarly, the SIM card shall be accessible without particular handling constraints, in case the SIM card is blocked or it is necessary to change the phone operator.
- **Sensor replacement:**
  - Similarly, and especially for the pressure, the user could replace the sensors according to the measurements to do.
- The water company should be able to do all the above listed handlings without any return of equipment to the manufacturer.

## **14.2.6 PLC EQUIPMENT**

### **14.2.6.1 QUALITY CRITERIA**

Equipment installed within the framework of this project of remote processing shall answer particularly the following criteria:

- A very high reliability to guarantee a maximal availability of the remote processing, even on very exposed sites.
- An important sustainability of the solutions proposed to allow for simple implementation of a future extension at the best cost.

An important simplicity of implementation and use to minimize the times for commissioning and to ensure control of this tool by the staff concerned without specific training.

### **14.2.6.2 ASSEMBLY IN CABINET**

The PLC can have risen in face before of an electric cabinet to reach the data of the PLC on the graphic screen (HMI) without having to open the cabinet.

### **14.2.6.3 MATERIAL**

#### **14.2.6.3.1 reliability and modularity**

To guarantee the reliability of equipment, the proposed PLC must be conceived with components allowing a high protection EMC (Electromagnetic Compatibility); that is the level 4 for the following standards:

- **IEC EN 61000-4-4:** Testing and measurement techniques - Electrical fast transient/burst immunity test.
- **IEC EN 61000-4-5:** Testing and measurement techniques - Surge immunity test.

Every PLC shall have modular architecture:

- On one hand, to fit at best the configuration of the post to the need for the installation.
- On the other hand, to allow extensions at lesser cost.

Finally the modularity shall facilitate the maintenance: the cards being independents, the one compared with the others, the diagnosis will be faster and the replacement of a defective card will be made very easily.

#### **14.2.6.3.2 electronic cards**

The non-exhaustive list of cards below can constitute a PLC following the needs for the site to be equipped:

- Inputs/Outputs Cards
  - Digital Input Card.
  - Analogic Input Card.
  - Digital Output Card + Guard dog.
  - Analogic Output Card (If later need).
- Cards of Communication
  - GSM Modem.
  - PSTN Modem.
  - Card for connections LS / LP.
  - Card for connections Ethernet.
  - Serial Interfaces RS232 / RS485.
  - Card for badge reader (Access control).

To facilitate the cabling, all the cards must be equipped with disconnectable terminal blocks.

Cards for the acquisition of the Analogue Inputs shall have to be capable of feeding directly the sensors 4-20 mA, without requiring the appeal to an external power supply. This power supply must be protected from the short circuits.

Cards for the acquisition of the Digital Inputs shall have to be of the type "in dry contact": they shall have to supply an opto-insulation and the power supply of the contacts via an isolated power supply besides with the equipment.

#### **14.2.6.3.3 power supply**

The power supply of the PLC is a sensitive part. The group constituted by the network power supply card and the safety power supply (battery / UPS) shall have to answer the following characteristics:

- A battery charger (plan a battery offering a minimal autonomy of 12 hours).
- A device against the deep discharges to protect the life expectancy of the battery during prolonged power break.
- A protection against the inversions of polarity.
- A presence detection battery.
- A periodic test of capacity of the battery.

This last function guarantees the efficiency of the battery while optimizing maintenance costs (the battery shall be only replaced on detection of insufficient capacity).

When network power supply does not exist the PLC shall be powered by a 7 year autonomy lithium battery.

#### **14.2.6.3.4 GSM Modem**

The modem GSM of the PLC is also an essential element because it assures the link with the control centre and the distant users. It shall therefore be of a high reliability and have a guarantee of sustainability.

The modem GSM shall be integrated into the PLC. It cannot involve an office automation modem or an external modem of the business, the characteristics of which are not adapted to remote processing applications.

The modem GSM shall be used for GPRS communication.

#### **14.2.6.4 FEATURES**

The PLC proposed shall assure the following functions:

- Acquisition of inputs - outputs.
  - Digital status (on/off, defaults, ...).
  - Measures (level, pressure, ...).
  - Counting (Flow, operating time, ...).
  - Command (opening/closing, ...).
  - Regulations (Instruction of flow, ...).

The acquisition of inputs-output shall be made by means of integrated or external input-output cards.

- Treatment of the acquired information
  - Measures (level, pressure, ...).
  - Warning levels.
  - Temporizations of the alarms.
  - Calculation of balance sheets.
  - Complete module for the archiving of the information and the events:
    - For the measures: periodic archiving of the value and on variation if the measure evolves in a significant way between 2 archivings.
    - For the Digital inputs - output: archiving in every change of state.
    - For the counting: periodic archiving or in the form of balance sheets.

All these treatments shall be configurable by the user, via an interface operator. Use of this interface operator should not require any IT programming skills.

- Transfer of alarms

The alarms shall be able to be transmitted by GSM in the form of vocal messages, of SMS or of Emails towards on-call agents, or towards control centre.

The authorized people shall be able to consult remotely at any time the information of the installation via the voice server or by SMS, so authorizing a big freedom of movement.

- Communication with other equipment

For the future evolutions, the PLC shall be capable of communicating with other equipment by using a standard protocol as the MODBUS or MODBUS-TCP.

- Interface Operator of exploitation

For the local exploitation, the PLC shall integrate a graphic screen allowing the consultation of states, alarms, values archived in the form of curve, and the positioning of the instructions (depending on the password entry).

For the remote exploitation, the PLC or GSM shall have a voice server allowing the management of the alarms, the consultation of states and the activation of commands.

Finally the PLC shall be totally accessible, in local and remote, via a simple Internet browser, on PC.

- Interface Operator of configuration

To assure its control by the concerned users, the tool of configuration shall be particularly intuitive and possess simple notions of "questions-answers" using the usual terms of the job (no specific language of programming). This tool of configuration should work on a standard PC and have graphical interfaces easy to treat.

- Automatism

The PLC should have a function allowing to realize simply combinations between digital inputs, or to make an elementary automatism. On the other hand, to answer needs for more elaborate automatisms (regulation, permutation / management of pumps, the PLC should have a language of standard automatism (according to the standard IEC1131-1) and libraries of functions ready for the use.

## **14.2.7 COMMUNICATIONS**

### **14.2.7.1 GENERAL**

The Contractor shall supply install and commission all necessary communications equipment and software to provide a complete integrated communications network for the SCADA system.

### **14.2.7.2 EMPLOYER LIAISON**

The Employer will be responsible for processing the cell phone contracts required from the national phone network operators.

The Contractor shall, however, provide all detail design calculations, equipment characteristics, equipment approval certificates and completed application forms for the Employer to enable the Employer to process all applications for communications circuits, frequencies etc. as an administrative task.

The Tenderer shall, within his bid, allow for all necessary tests to prove compatibility of the offered equipment with the national phone network operators and communications standards.

### **14.2.7.3 TRANSMISSION AND PROTOCOL**

The Contractor shall wherever possible use an industry standard transmission protocol. The Contractor shall provide details of the proposed protocol to be used at the time of Tender.

### **14.2.7.4 ELECTRONIC EQUIPMENT**

All communications equipment used in the communications system shall be of high reliability and shall comply with the most recent edition of appropriate National and International Standards Specifications and recommendations at the time of Tender.

## **14.2.8 LIGHTNING PROTECTION**

### **14.2.8.1 LIGHTNING PROTECTION DEVICES**

The Contractor shall provide lightening and surge protection devices at each data logger and PLC on each communications circuit to ensure isolation and automatic resetting of the system being subject to high surge currents. Devices shall not be a fused type.

Lightning protection shall conform to the appropriate sections of BS6651, code of practice for protection of structures against lightning.

Lightning protection shall be selected to provide the highest degree of protection possible for the circuit being protected i.e. the clamp voltage shall be the lowest possible commensurate with normal operation of the circuit.

The type and manufacturer of the Lightning Protection Unit (LPU) shall be subject to the approval of the Engineer.

LPUs shall be earthed to the nearest earth reference bar, as direct as possible without inductive loops by one single-piece cable.

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Individual LPUs shall bolt directly onto a lightning earth bus bar. Cables and cores containing the circuits to be protected shall not be loomed or grouped together until the circuits subject to induced lightning energy have passed through the protection units.

Where two or more LPUs are mounted on the same DIN rail mounted earth bar, the cable shall be sized as follows:

- Cables less than 6 metres: 10 sq. mm.
- Cables greater than 6 metres: 16 sq. mm.

The whole assembly shall be mounted inside an insulated box, if not already mounted separately from other equipment, close to the chosen earth termination in order to achieve a short, straight connection.

LPUs that are mounted in an enclosure supplied with an a.c. electrical power supply that utilise DIN rail mounted earth bars shall have either:

- The earth bars insulated by means of proprietary stand-offs or.
- The DIN rail insulated in an approved manner from the electrical power earth or any earthed conducting surface.

The route for the earth conductor shall be as far away as possible from the vicinity of the signal cables.

The earth conductor shall be copper, no greater than 16 sq. mm in section, its route shall be as short and direct as possible and, in any case, no longer than 10 metres.

Ideally the cable route should be straight, but any necessary bends shall have a long radius.

The earth termination and the method of connection shall be subject to the approval of the Engineer.

### 14.2.8.2 EARTH ELECTRODES

The Contractor shall provide an earth electrode system in cases where the contract provides for the facility of lightning surge diversion equipment. The system shall be cabled to the main protective conductor system at the common point of connection of the distribution system that it serves.

Earth electrode systems shall be provided where specified in the particular Specification.

Where the provision of lightning protection is specified, the Contractor shall provide an earth electrode system in accordance with the relevant code of practice.

### 14.2.8.3 EARTH ELECTRODE INSTALLATION

Earth electrode installation shall connect earthing conductors to the general mass of the earth. The installation shall comprise one or more earth rods, mesh or combination thereof to obtain the required earth electrode resistance.

Earth rods shall be of proprietary manufacture, 16 mm outer diameter, made up of sections of 1.2 metres long with internal screw and socket joints and fitted with hardened steel tip and driving cap. They shall be driven into the ground to a minimum of 2.4 metres.

A minimum of two earth rods or other electrode shall be provided for each main earthing system and the conductor brought back to the main earth bus bar for each.

Connections to the electrodes are to be readily accessible for periodic inspection and shall be protected against mechanical damage and corrosion. The actual connection to the rod shall be by means of a purpose made non ferrous clamp and shall be made below ground level in a concrete inspection pit having a removable cover.

When the installation is complete, soil resistivity or other tests shall be performed and witnessed by the Engineer, to ensure that the required earth loop impedance figure of less than 5 ohms is attained.

## **14.3 EXECUTION**

### **14.3.1 TESTING**

The Contractor shall provide for system testing as detailed. The tests shall conform to BS 5887 (code of practice for testing of computer based systems) and BS 6238 (code of practice for performance monitoring of computer based systems).

The Engineer shall approve all acceptance procedures for inclusion within the system specification.

### **14.3.2 FACTORY ACCEPTANCE TEST**

#### **14.3.2.1 GENERAL**

The Tenderer shall provide for full Factory Acceptance Test of the fully configured system, to include:

- The complete system network.
  - Support for all data loggers and PLCs with all points over an integrated network, simulated to include all types of communications units and interfaces.
- Mimic display pages on the system as defined within the particular specification.
- Test 1 - Simultaneous occurrence of:
  - The control centre polling outstations in normal (i.e. daytime) operational mode receiving 50% of data from each data logger or PLC with 10% of points in alarm conditions.
  - Operator workstations performing:
    - Simultaneous access.
    - Access staggered by 2 seconds.
- Test 2:
  - As test 1.
  - Performing daily system archive.
- Test 3:
  - As test 1.
  - Performing archive data recovery.
    - Full daily archive recovery.
    - Four data points for one week (15 minute intervals).
- Test 4:
  - As test 1.
  - Performing screen dump.
  - Printing daily report.

The simulation package shall use the SCADA system to demonstrate proper performance under full utilisation conditions.

The Contractor shall record the following:

- DISPLAY RESPONSE: This shall be no greater than as specified.
- PERCENTAGE CPU UTILISATION.

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- SCAN TIME: This shall be no greater than 1 minute for full system scanning.
- TIME TO CLEAR BACKLOG: The Contractor shall also record any adverse conditions that become apparent.

The Contractor shall substantiate the validity of the simulation to the Engineer and shall confirm, at the time of Tender, by what means such simulation shall be carried out.

- The data logger /PLC to demonstrate:
  - All control and failure recovery sequences, simulating all digital and analogue inputs and outputs on each system.
- The communications system to demonstrate:
  - Full simulation utilising all interface nodes, with data loggers and PLCs connected, in order to prove the performance over the network. Communications failures shall be simulated in order to prove the automatic re-routing of communications to SCADA system.

### 14.3.2.2 FACTORY ACCEPTANCE TEST - WITNESSING

The Factory Acceptance Test shall be conducted in the presence of witnesses, who shall be nominated, in writing, by the Employer and the Contractor respectively. The witnesses shall be empowered to act during the Factory Acceptance Test, on behalf of the parties they represent, to judge the success or failure of a particular test. Either party as necessary, in writing may appoint nominated Deputies.

The Contractor shall provide evidence that the tests (FAT/SAT) have been successfully performed prior to the witnessing by the Engineer.

### 14.3.2.3 FACTORY ACCEPTANCE TEST - PROCEDURES

The testing procedures shall be designed such that each separate testable entity (e.g. hardware configuration, picture building) consists of a well-defined series of tests.

Each test shall be documented to include:

- The purpose of the test.
- Any pre-requisites required allowing the test to be completed successfully.
- Any hardware required allowing the test to be performed successfully.
- A detailed schedule of activities to be performed within the test.

### 14.3.2.4 FACTORY ACCEPTANCE TEST - RECORD

A log shall be maintained during the Factory Acceptance Test. This log shall record for each test performed:

- The test results.
- Any faults which occur.
- Any remedial action taken.
- Re-test results.
- Decisions taken by the witnesses which may affect the test results.

The witnesses of both parties shall initial all entries within the log.

Copies of the log shall be provided to the Employer on completion of the Factory Acceptance Test.

### 14.3.2.5 FAILURE AND RE-TEST

The success or failure shall be determined as follows:

- If the system performs as laid down in the Functional Design Specification the test shall be deemed successful.
- The tests shall not be failed due to external conditions, e.g. power fail, provided the system fulfils the resilience criteria detailed within this tender document and any subsequent project specification.
- The tests shall not be failed through incorrect operation provided the fault can be corrected by normal operating procedures and provided the test performed satisfactorily in all other aspects (e.g. printer ribbon failure).

Any test that is deemed unsuccessful may be retried following any remedial action that may be necessary.

If the system should fail any test and it is apparent that the fault may have affected the result of tests previously regarded as successful any or all of the tests affected may be re-tested.

To allow all participants to fully understand all aspects of the Factory Acceptance Test, the Factory Acceptance Test Specification as agreed between all parties shall be issued with the Contractor's Inspection and Test Plan (ITP).

#### **14.3.2.6 SYSTEM MANAGEMENT**

The Factory Acceptance Test shall include, but not be limited to, the following as defined within Contractor's Project Specification.

- Hardware
  - The hardware configuration being tested shall be fully detailed and cross-referenced against the Tender Return Document.
- System Start-up and Shut-down Procedures
  - These tests shall exercise the system start-up and shut-down commands including:
    - System start-up commands.
    - Operator log-in and log-out commands.
    - Password verification.
    - Any special function command keys.
    - Orderly system shut-down.
- System Back-up and Recovery
  - These tests shall exercise the system back-up and recovery procedures, including:
    - System back-up to archive media.
    - Orderly system shut-down.
    - Synchronisation of the Master Station and outstations.

#### **14.3.2.7 SCADA DATA BASE CONFIGURATION**

These tests shall exercise the database commands including:

- Password and level of access maintenance.
- The creation and amendment of data loggers and PLCs.
- The maintenance of data logger and PLCs communications parameters, e.g. telephone numbers, radio characteristics, change of media, scanning intervals, on/off telemetry scan.
- Zone of interest.
- Creation and amendment of SCADA points:
  - Name.

- Type, e.g. status, analogue, derived.
- Alarm limits.
- Historic data recording and characteristics.
- Re-transmission of value to associated points.
- Scaling factors.
- Calculation formulae maintenance.
- Set output control parameters for digital, analogue and derived controls.

#### **14.3.2.8 PICTURE CONFIGURATION**

The tests shall exercise the picture configuration commands available to the privileged operators, including:

- The creation of picture pages, to include foreground/dynamic and background/static picture elements.
- The modification of picture pages, to include foreground/dynamic and background/static picture elements.
- The deletion, copying and renaming of pictures.
- Any function control key usage.
- Examples of all picture types, e.g.:
  - Static information pages (e.g. indices).
  - Mimic pictures for information display and control monitoring.
  - Alarm list pages.
  - Statistical pictures (e.g. trends, histograms).
  - Help/text pages.
- The display and printing of pictures.

#### **14.3.2.9 DATA COLLECTION**

These tests shall exercise the data collection commands available to the privileged operators, including:

- The collection of digital, analogue and derived parameters.
- The collection of all data from outstations at frequencies defined by the privileged operator.
- The manual entry of data.
- The inhibition of data collection from a data logger and from a PLC.
- The inhibition of data collection from an individual point.
- The editing of stored data (subject to correct level of access).

#### **14.3.2.10 SUPERVISORY CONTROL**

These tests shall exercise the supervisory control commands, including:

- The creation and down line loading of control sequences.
- Digital, e.g. open/close, and analogue, e.g. set point, controls of individual control points.
- Reversed checks to ensure the correct control point is addressed.

#### **14.3.2.11 ALARM/EVENT HANDLING**

These tests shall exercise the alarm and event reporting procedures, including:

- Digital and analogue alarms:
  - Reported on the alarm/event printer.
  - Logged to disc.
  - Reported to the appropriate operator consoles.
- Events, e.g. issue remedial control command:
  - Are only issued from appropriate operator consoles.
  - Logged to the alarm/event printer.
  - Logged to disc.
  - Are subject to correct level of access and regions of interest.
- Alarm acceptance/acknowledgement procedures.
- Alarm list interrogation procedures.
- Alarm list printing.
- Alarm inhibit for an individual point.

#### **14.3.2.12 DATA LOGGING**

These tests shall exercise the data logging and archiving procedures including:

- Tests to ensure all data/alarms collected are logged to the on-line archive storage.
- Tests to ensure data can be archived to and recalled from long term archive media.

#### **14.3.2.13 DATA LOGGER AND PLC PROGRAMMING**

These tests shall exercise the data logger and PLC sequence programming procedures, including:

- Sequence program editing, compilation and loading.
- The ability to load new sequences on demand by a privileged operator.

#### **14.3.2.14 MANAGEMENT INFORMATION SYSTEM DEVELOPMENT**

These tests shall demonstrate the use of the enquiry package and the applications programs development tool kit, including:

- The editing and compilation of programs.
- The abstracting of data from the SCADA database.
- The automatic scheduling of programs as a result of time of day queues and as a result of a SCADA event/alarm.

### **14.3.3 SITE ACCEPTANCE TESTS**

The Contractor shall provide for full site acceptance tests for each item of the water supply system to be provided under the Contract. This shall include the interface to the connections unit, the communication system, the earthing system and full functionality as demonstrated at the Factory Acceptance Test.

### **14.3.4 SYSTEMS ACCEPTANCE TESTS**

The Contractor shall provide for full system test on completion to include tests as stated above. All special test equipment relevant to the Contractor supplied equipment shall become the property of the Employer on completion.

### **14.3.5 COMMUNICATION EQUIPMENT TESTING**

The Contractor shall allow for the following tests with regard to communications equipment:

- Factory testing of sub-assemblies
- Factory testing of complete units.
- Factory simulated system tests to prove the performance of all elements of the integrated communications network.
- Commissioning tests of all installed radio equipment to record the characteristics for future maintenance of the network

Test certificates shall be provided at each stage and for each complete unit and sub-system. The Contractor shall supply all test equipment and shall provide a seven day notice prior to testing to the Engineer.

### **14.3.6 DELIVERY AND INSTALLATION**

#### **14.3.6.1 SCOPE**

The Contractor shall be responsible for all costs involved with the delivery and installation of the equipment for the system.

#### **14.3.6.2 DELIVERY**

The Contractor shall provide all personnel and equipment necessary to unload the equipment and transport the equipment to its' final location.

##### **14.3.6.2.1 Installation**

The Contractor should be aware that there may be periods such as flood events or operational reasons, for which the Contractor will not be allowed to work on the system or some particular part of the system or data loggers / PLCs, for some specified period.

The Contractor shall make due allowances for this in his costing and programming of his installation and commissioning works.

### **14.3.7 SYSTEM RECOVERY**

The Contractor shall supply a full backup set of the supplied software, on suitable archival media (e.g., CD-ROM, optical disk, etc.). The Contractor shall also himself keep a full backup of the supplied software for the life cycle of the supplied equipment.

### **14.3.8 TRAINING**

The Contractor shall at time of tender state any minimum levels of training/experience required for participants, prior to attending the appropriate course.

The Contractor shall provide training for the Purchaser's staff as detailed. The Tenderer may offer training courses structured to meet his technical offering. These courses shall be subject to the approval of the Engineer and shall be detailed at the time of Tender.

In general training courses shall be provided at Purchaser's offices as detailed within the particular specification. However some courses may be held at the manufacturer's works as agreed by the Purchaser.

The Contractor shall provide all course materials and equipment needed.

The training shall be organised such that the Purchaser shall be able to operate and maintain the SCADA scheme following completion of all training courses.

#### **14.3.8.1 SYSTEMS OPERATORS**

The Contractor shall provide for the number of attendees as specified within the Particular Specification with 4 no. operators attending each course.

This purpose-designed course is to be held at the Works Control Centre. Training must be provided in advance of commissioning to enable the Purchaser's user staff to participate in the full process commissioning of the system and safely operate the facilities and maintain the SCADA system.

System take-over shall not take place until satisfactory training has been provided.

This course shall be designed to familiarise the participants with the general running of the standard operating system and the SCADA package to include but not limited to:

- Loading and starting up the Operating System.
- System Operators interface.
- Operator control of program/task execution.
- Operator control of disc files.
- File transfer tasks - archiving, retrieval.
- Operator response to system failure, on-line/off-line diagnostics, transfer of control between the computers synchronisation of the system database.
- SCADA system interrogation facilities - alarm lists, log printouts select mimic and trend displays etc..
- Alarm acknowledge accept/delete.
- Control actions, e.g. start pump, close valve.
- All functions associated with each access level of the SCADA system.

#### **14.3.8.2 SYSTEM SUPERVISOR PERSONNEL**

The Contractor shall provide a five-day course for the number of attendees as specified within the Particular Specification.

To be held at the Works Control Centre prior to the systems hand-over and shall consist of all of the above tasks plus:

- Basic systems design overview.
- The use of computers to perform diagnostics and to tune other parts of the system.
- Changing passwords and access control.
- Sequence verification.
- Preventative maintenance.

#### **14.3.8.3 SYSTEMS DEVELOPERS/PROGRAMMERS/ENGINEERS**

The Contractor shall provide 1 no. five day course with the number of attendees as specified within the Particular Specification.

This course shall be designed to cover all configuration and advanced facilities of the SCADA package. To include, but not be limited to:

- The system database structure.
- System database building/configuration.

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- Mimic building.
- Applications program interface to the system database.
- Management information system interface.
- Downtime loading of control programs/sequences to data loggers and PLCs.
- Advanced operating features.

### 14.3.8.4 SITE TRAINING

The Contractor shall provide the following training at minima:

Subject	Approximated number of trainee	Duration
Project description and SCADA architecture	15	1 day
SCADA system equipment utilization	15	2 days
SCADA system equipment programming	15	5 days
SCADA Control Center utilization	15	5 days
SCADA Control Center programming	5	5 days

The Contractor shall supply O & M and training documentation 2 weeks prior to training. Any part of the water supply system shall not be handed to the Purchaser for operation until training on the control systems has been completed. Should defects occur prior to Take-over of the whole scheme the Contractor shall be responsible for rectifying the fault prior to any other phased hand-over of the scheme.

This training course/workshop shall be designed as a "reference" course rather than a formal educational course, i.e. the Contractor's personnel shall be present to assist the Purchaser's personnel, as necessary, with any technical difficulties.

### 14.3.9 SPARES AND TEST EQUIPMENT

The Contractor shall provide spare parts for 2 year operation of the new SCADA system features.

In addition, he should provide test equipment for commissioning period.

To minimise the spares holding, the Contractor's design should consider the benefits of standardisation.